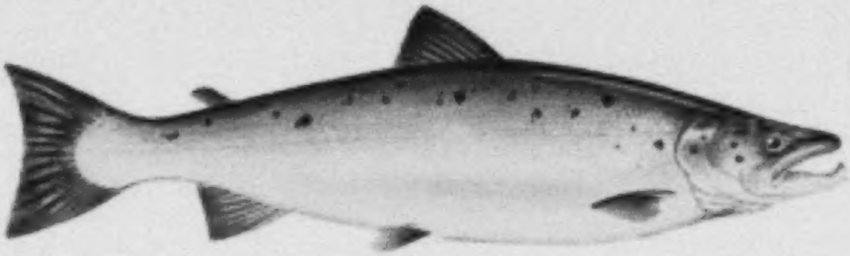
COSEWIC
Assessment and Status Report

on the

Atlantic Salmon
Salmo salar

Nunavik population, Labrador population, Northeast Newfoundland population, South Newfoundland population, Southwest Newfoundland population, Northwest Newfoundland population, Quebec Eastern North Shore population, Quebec Western North Shore population, Anticosti Island population, Inner St. Lawrence population, Lake Ontario population, Gaspé-Southern Gulf of St. Lawrence population, Eastern Cape Breton population, Nova Scotia Southern Upland population, Inner Bay of Fundy population, Outer Bay of Fundy population

in Canada



Nunavik Population – DATA DEFICIENT
Labrador Population – NOT AT RISK
Northeast Newfoundland Population – NOT AT RISK
South Newfoundland Population – THREATENED
Southwest Newfoundland Population – NOT AT RISK
Northwest Newfoundland Population – NOT AT RISK
Quebec Eastern North Shore Population – SPECIAL CONCERN
Quebec Western North Shore Population – SPECIAL CONCERN
Anticosti Island Population – ENDANGERED
Inner St. Lawrence Population – SPECIAL CONCERN
Lake Ontario Population – EXTINCT
Gaspe-Southern Gulf of St. Lawrence Population – SPECIAL CONCERN
Eastern Cape Breton Population – ENDANGERED
Nova Scotia Southern Upland Population– ENDANGERED
Inner Bay of Fundy Population – ENDANGERED
Outer Bay of Fundy Population – ENDANGERED
2010

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

COSEWIC. 2010. COSEWIC assessment and status report on the Atlantic Salmon *Salmo salar* (Nunavik population, Labrador population, Northeast Newfoundland population, South Newfoundland population, Southwest Newfoundland population, Northwest Newfoundland population, Quebec Eastern North Shore population, Quebec Western North Shore population, Anticosti Island population, Inner St. Lawrence population, Lake Ontario population, Gaspé-Southern Gulf of St. Lawrence population, Eastern Cape Breton population, Nova Scotia Southern Upland population, Inner Bay of Fundy population, Outer Bay of Fundy population) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xlvii + 136 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Previous report(s):

COSEWIC. 2006. COSEWIC assessment and status report on the Atlantic Salmon *Salmo salar* (Lake Ontario population) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 26 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

COSEWIC. 2006. COSEWIC assessment and update status report on the Atlantic Salmon *Salmo salar* (Inner Bay of Fundy populations) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. viii + 45 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

COSEWIC. 2001. COSEWIC assessment and status report on the Atlantic Salmon *Salmo salar* (Inner Bay of Fundy populations) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 52 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Amiro, P.G. 2001. COSEWIC status report on the Atlantic Salmon *Salmo salar* (Inner Bay of Fundy populations) in Canada, *in* COSEWIC assessment and status report on the Atlantic Salmon *Salmo salar* (Inner Bay of Fundy populations) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1-52 pp.

Production note:
COSEWIC acknowledges Blair K. Adams and David Cote for writing the status report on Atlantic Salmon *Salmo salar* (anadromous form) in Canada, prepared under contract with Environment Canada. This report was overseen by Paul Bentzen, Co-chair of the COSEWIC Marine Fishes Species Specialist Subcommittee with the assistance of Jamie Gibson, member of the COSEWIC Marine Fishes Species Specialist Subcommittee.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le saumon atlantique (*Salmo salar*) au Canada.

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Atlantic Salmon — Line drawing of Atlantic salmon *Salmo salar* from Amiro (2003).

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COSEWIC
Assessment Summary

Assessment Summary – November 2010

Common name
Atlantic Salmon – Nunavik population

Scientific name
Salmo salar

Status
Data deficient

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and several years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population, which breeds in rivers flowing into Ungava Bay and eastern Hudson Bay, is the northernmost population of the species in North America, and the westernmost population of the entire species. It is separated by approximately 650 km from the nearest population to the south. Little is known about abundance trends in this population, although limited catch per unit effort data suggest increased abundance in recent years.

Occurrence
Quebec, Newfoundland and Labrador, Atlantic Ocean

Status history
Species considered in November 2010 and placed in the Data Deficient category.

Assessment Summary – November 2010

Common name
Atlantic Salmon – Labrador population

Scientific name
Salmo salar

Status
Not at risk

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and several years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers along the Atlantic coast of Labrador and southwest along the Quebec coast to the Napetipi Rivers (inclusive). Freshwater habitats remain largely pristine. Abundance data are not available for most rivers; however, for rivers for which data are available, the number of mature individuals appears to have increased by about 380% over the last 3 generations.

Occurrence
Newfoundland and Labrador, Atlantic Ocean

Status history
Designated Not at Risk in November 2010.

Assessment Summary – November 2010

Common name
Atlantic Salmon – Northeast Newfoundland population

Scientific name
Salmo salar

Status
Not at risk

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers along the northeast coast of Newfoundland, from the northern tip of the island to the southeastern corner of the Avalon Peninsula. Recent abundance data show no clear trends in the number of mature individuals. Since 1992, the negative effects of poor marine survival have been at least partially offset by a near cessation of fishing mortality in coastal fisheries. Illegal fishing is a threat in some rivers.

Occurrence
Newfoundland and Labrador, Atlantic Ocean

Status history
Designated Not at Risk in November 2010.

Assessment Summary – November 2010

Common name
Atlantic Salmon – South Newfoundland population

Scientific name
Salmo salar

Status
Threatened

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers from the southeast tip of the Avalon Peninsula, Mistaken Point, westward along the south coast of Newfoundland to Cape Ray. The numbers of small (one-sea-winter) and large (multi-sea-winter) salmon have both declined over the last 3 generations, about 37% and 26%, respectively, for a net decline of all mature individuals of about 36%. This decline has occurred despite the fact that mortality from commercial fisheries in coastal areas has greatly declined since 1992; this may be due to poor marine survival related to substantial but incompletely understood changes in marine ecosystems. Illegal fishing is a threat in some rivers. The presence of salmon aquaculture in a small section of this area brings some risk of negative effects from interbreeding or adverse ecological interactions with escaped domestic salmon. Genetic heterogeneity among the many small rivers in this area is unusually pronounced, suggesting that rescue among river breeding populations may be somewhat less likely than in other areas.

Occurrence
Newfoundland and Labrador, Atlantic Ocean

Status history
Designated Threatened in November 2010.

Assessment Summary – November 2010

Common name
Atlantic Salmon – Southwest Newfoundland population

Scientific name
Salmo salar

Status
Not at risk

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers from Cape Ray northwards along the west coast of Newfoundland to approximately 49°24' N, 58°15' W. Both small (one-sea-winter) and large (multi-sea-winter) salmon have increased in number over the last 3 generations, about 132% and 144%, respectively, giving an increase in the total number of mature individuals of about 134%.

Occurrence
Quebec, Newfoundland and Labrador, Atlantic Ocean

Status history
Designated Not at Risk in November 2010.

Assessment Summary – November 2010

Common name
Atlantic Salmon – Northwest Newfoundland population

Scientific name
Salmo salar

Status
Not at risk

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers along the west coast of Newfoundland from approximately 49°24' N, 58°15' W to the tip of the Great Northern Peninsula. The total number of mature individuals appears to have remained stable over the last 3 generations, and the number of large (multi-sea-winter) salmon appears to have increased by about 42%.

Occurrence
Newfoundland and Labrador, Atlantic Ocean

Status history
Designated Not at Risk in November 2010.

Assessment Summary – November 2010

Common name
Atlantic Salmon – Quebec Eastern North Shore population

Scientific name
Salmo salar

Status
Special concern

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers along the north shore of the St. Lawrence River estuary from the Napetipi River (not inclusive) westward to the Kegaska River (inclusive). This population shows opposing trends in the abundance of small (1 sea-winter) and large (multi-sea-winter) fish. Small salmon have declined 26% over the last 3 generations, whereas large salmon have increased 51% over the same period; pooling the data for both groups suggests a decline of about 14% for all mature individuals considered together. The small size of the population, about 5000 mature fish in 2008, is cause for concern. As is the case for most populations of the species, poor marine survival related to substantial but incompletely understood changes in marine ecosystems is also a concern.

Occurrence
Quebec, Atlantic Ocean

Status history
Designated Special Concern in November 2010.

Assessment Summary – November 2010

Common name
Atlantic Salmon – Quebec Western North Shore population

Scientific name
Salmo salar

Status
Special concern

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers along the north shore of the St. Lawrence River from the Natashquan River (inclusive) to the Escoumins River in the west (inclusive). Small (one-sea-winter) and large (multi-sea-winter) fish have both declined over the last 3 generations, approximately 34% and 20%, respectively, for a net decline of all mature individuals of about 24%. As is the case for most populations of the species, poor marine survival related to substantial but incompletely understood changes in marine ecosystems is a concern.

Occurrence
Quebec, Atlantic Ocean

Status history
Designated Special Concern in November 2010.

Assessment Summary – November 2010

Common name
Atlantic Salmon – Anticosti Island population

Scientific name
Salmo salar

Status
Endangered

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers on Anticosti Island. Small (one-sea-winter) and large (multi-sea-winter) fish have both declined over 3 generations, approximately 32% and 49%, respectively, for a net decline of all mature individuals of about 40%. The population size is small, about 2,400 individuals in 2008. As is the case for most populations of the species, poor marine survival related to substantial but incompletely understood changes in marine ecosystems is a concern.

Occurrence
Quebec, Atlantic Ocean

Status history
Designated Endangered in November 2010.

Assessment Summary – November 2010

Common name
Atlantic Salmon – Inner St. Lawrence population

Scientific name
Salmo salar

Status
Special concern

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This highly managed population breeds in rivers tributary to the St. Lawrence River upstream from the Escoumins River (not included) on the north shore and the Ouelle River (included) on the south shore. Small (one-sea-winter) and large (multi-sea-winter) fish have both remained approximately stable in abundance over the last 3 generations. The small size of the population, about 5,000 individuals in 2008, is of concern. The rivers in this area are close to the largest urban areas in Quebec and the population has undergone a large historical decline due to loss of habitat. As is the case for most populations of the species, poor marine survival related to substantial but incompletely understood changes in marine ecosystems is a concern.

Occurrence
Quebec, Atlantic Ocean

Status history
Designated Special Concern in November 2010.

Assessment Summary – November 2010

Common name
Atlantic Salmon – Lake Ontario population

Scientific name
Salmo salar

Status
Extinct

Reason for designation
Once a prolific resident throughout the Lake Ontario watershed, there has been no record of this population since 1898. The Lake Ontario population was extinguished through habitat destruction and through over-exploitation by food and commercial fisheries. As the original strain is gone, re-introduction is not possible. Recent attempts to introduce other strains of the species have resulted in some natural reproduction, but no evidence of self-sustaining populations.

Occurrence
Ontario, Atlantic Ocean

Status history
Last reported in 1898. Designated Extirpated in April 2006. Status re-examined and designated Extinct in November 2010.

Assessment Summary – November 2010

Common name
Atlantic Salmon – Gaspé-Southern Gulf of St. Lawrence population

Scientific name
Salmo salar

Status
Special concern

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers from the Ouelle River (excluded) in the western Gaspé Peninsula southward and eastward to the northern tip of Cape Breton. Small (one-sea-winter) and large (multi-sea-winter) fish have both declined over the last 3 generations, approximately 34% and 19%, respectively, for a net decline of all mature individuals of about 28%. This recent 3-generation decline represents a continuation of a decline extending back at least to the 1980s. The number of mature individuals remains over 100,000; however, the majority spawn in a single major river system, the Miramichi, in New Brunswick. Freshwater habitat quality is a concern in some areas, particularly in Prince Edward Island where some remaining populations are maintained by hatchery supplementation. Invasive and illegally introduced species, such as smallmouth bass, are a poorly understood threat in some freshwater habitats. Poor marine survival is related to substantial but incompletely understood changes in marine ecosystems.

Occurrence
Quebec, New Brunswick, Nova Scotia, Atlantic Ocean

Status history
Designated Special Concern in November 2010.

Assessment Summary – November 2010

Common name
Atlantic Salmon – Eastern Cape Breton population

Scientific name
Salmo salar

Status
Endangered

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in Cape Breton Island rivers draining into the Atlantic Ocean and Bras d'Or Lakes. The numbers of adults returning to spawn has declined by about 29% over the last 3 generations; moreover, these declines represent continuations of previous declines. The total number of mature individuals in 5 rivers, thought to harbour the majority of the population, was only about 1150 in 2008. There is no likelihood of rescue, as neighbouring regions harbour genetically dissimilar populations, and the population to the south is severely depleted. A current threat is poor marine survival related to substantial but incompletely understood changes in marine ecosystems.

Occurrence
Nova Scotia, Atlantic Ocean

Status history
Designated Endangered in November 2010.

Assessment Summary – November 2010

Common name
Atlantic Salmon – Nova Scotia Southern Upland population

Scientific name
Salmo salar

Status
Endangered

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers from northeastern mainland Nova Scotia, along the Atlantic coast and into the Bay of Fundy as far as Cape Split. Small (one-sea-winter) and large (multi-sea-winter) fish have both declined over the last 3 generations by approximately 59% and 74%, respectively, for a net decline of all mature individuals of about 61%. Moreover, these declines represent continuations of greater declines extending far into the past. During the past century, spawning occurred in 63 rivers, but a recent (2008) survey detected juveniles in only 20 of 51 rivers examined. There is no likelihood of rescue, as neighbouring regions harbour severely depleted, genetically dissimilar populations. The population has historically suffered from dams that have impeded spawning migrations and flooded spawning and rearing habitats, and other human influences, such as pollution and logging, that have reduced or degraded freshwater habitats. Acidification of freshwater habitats brought about by acidic precipitation is a major, ongoing threat, as is poor marine survival related to substantial but incompletely understood changes in marine ecosystems. There are a few salmon farms in this area that could lead to negative effects of interbreeding or ecological interactions with escaped domestic salmon.

Occurrence
Nova Scotia, Atlantic Ocean

Status history
Designated Endangered in November 2010.

Assessment Summary – November 2010

Common name
Atlantic Salmon – Inner Bay of Fundy population

Scientific name
Salmo salar

Status
Endangered

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population once bred in 32 rivers tributary to the inner Bay of Fundy, from just east of the Saint John River, to the Gaspereau River in Nova Scotia; however, spawning no longer occurs in most rivers. The population, which is thought to have consisted of about 40,000 individuals earlier in the 20th century, is believed to have been fewer than 200 individuals in 2008. Survival through the marine phase of the species' life history is currently extremely poor, and the continued existence of this population depends on a captive rearing program. There is no likelihood of rescue, as neighbouring regions harbour severely depleted, genetically dissimilar populations. The population has historically suffered from dams that have impeded spawning migrations and flooded spawning and rearing habitats, and other human influences, such as pollution and logging, that have reduced or degraded freshwater habitats. Current threats include extremely poor marine survival related to substantial but incompletely understood changes in marine ecosystems, and negative effects of interbreeding or ecological interactions with escaped domestic salmon from fish farms. The rivers used by this population are close to the largest concentration of salmon farms in Atlantic Canada.

Occurrence
New Brunswick, Nova Scotia, Atlantic Ocean

Status history
Designated Endangered in May 2001. Status re-examined and confirmed in April 2006 and November 2010.

Assessment Summary – November 2010

Common name
Atlantic Salmon – Outer Bay of Fundy population

Scientific name
Salmo salar

Status
Endangered

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers tributary to the New Brunswick side of the Bay of Fundy, from the U.S. border to the Saint John River. Small (one-sea-winter) and large (multi-sea-winter) fish have both declined over the last 3 generations, approximately 57% and 82%, respectively, for a net decline of all mature individuals of about 64%; moreover, these declines represent continuations of greater declines extending far into the past. There is no likelihood of rescue, as neighbouring regions harbour severely depleted, genetically dissimilar populations. The population has historically suffered from dams that have impeded spawning migrations and flooded spawning and rearing habitats, and other human influences, such as pollution and logging, that have reduced or degraded freshwater habitats. Current threats include poor marine survival related to substantial but incompletely understood changes in marine ecosystems, and negative effects of interbreeding or ecological interactions with escaped domestic salmon from fish farms. The rivers used by this population are close to the largest concentration of salmon farms in Atlantic Canada.

Occurrence
New Brunswick, Atlantic Ocean

Status history
Designated Endangered in November 2010.

COSEWIC
Executive Summary

Atlantic Salmon
Salmo salar

Nunavik population, Labrador population, Northeast Newfoundland population, South Newfoundland population, Southwest Newfoundland population, Northwest Newfoundland population, Quebec Eastern North Shore population, Quebec Western North Shore population, Anticosti Island population, Inner St. Lawrence population, Lake Ontario population, Gaspé-Southern Gulf of St. Lawrence population, Eastern Cape Breton population, Nova Scotia Southern Upland population, Inner Bay of Fundy population, Outer Bay of Fundy population

Wildlife species information

The Atlantic Salmon (*Salmo salar*) is a member of the family Salmonidae. This species has a fusiform body shape and matures at sizes ranging from 10 to 100+ cm. Atlantic Salmon exhibit plastic life histories and may have multiple reproductive and migratory phenotypes within a population, including freshwater resident and oceanic migrant forms. All phenotypes reproduce in fresh water. The oceanic migrant (anadromous) form is the best known phenotype, and with the exception of the extinct Lake Ontario population, is the only form considered in this report. Juveniles spend 1-8 years in fresh water, then migrate to the North Atlantic for 1-4 years, and then return to fresh water to reproduce. Demographically functional units tend to be at the watershed scale, but population subdivision may occur within watersheds. The Canadian range of this species was subdivided into 16 designatable units (DUs) based on genetic data and broad patterns in life history variation, environmental variables, and geographic separation.

Distribution

Atlantic Salmon originally occurred in every country whose rivers flow into the North Atlantic Ocean and Baltic Sea. In Europe, the range of the Atlantic Salmon extended southward from northern Norway and Russia along the Atlantic coastal drainage to Northern Portugal, including rivers in both France and Spain. In North America, the range of the anadromous Atlantic Salmon was northward from the Hudson River drainage in New York State, to outer Ungava Bay and eastern Hudson Bay in Quebec. The Canadian range is roughly one-third the area of the total global range, and extends northward from the St. Croix River (at the border with Maine, U.S.A.) to the outer Ungava Bay and eastern Hudson Bay in Quebec. Recent estimates suggest Canada has at least 700 rivers which either currently support Atlantic Salmon populations, or did so in the past.

Habitat

Rivers with Atlantic Salmon are generally clear, cool and well oxygenated, with low to moderate gradient, and possessing bottom substrates of gravel, cobble and boulder. Freshwater habitat is considered a limiting resource to freshwater production and is used to set conservation requirements for Canadian rivers. There have been substantial declines in habitat quantity and quality in the southern portion of the species' Canadian range. This loss of freshwater habitat may be an important risk factor for declining abundance in several southern DUs. Trends in the quality and quantity of marine habitat are not well understood, but large-scale changes in ocean ecosystems may be adversely affecting Atlantic Salmon across their range.

Biology

Atlantic Salmon is an iteroparous species that returns to natal rivers to spawn with a high degree of fidelity, despite completing ocean-scale migrations. Spawners returning to rivers are comprised of varying proportions of 'maiden fish' (those spawning for the first time) and 'repeat spawners'. Maiden salmon consist of smaller fish that return to spawn after one winter at sea (1SW or Grilse) and larger fish that return after two or more winters at sea (MSW). Some river populations include fish that return to spawn after only a few months at sea. During any breeding season, there can be varying proportions of maiden, consecutive and alternate spawners in the spawning runs. Collectively over the entire range in North America, adult Atlantic Salmon return to rivers from feeding and staging areas in the sea mainly between May and November, but some runs can begin as early as March and April. In general, run timing varies by river, sea age, year, and hydrological conditions. Deposition of eggs in gravel nests, by oviparous mothers, usually occurs in October and November in gravel-bottomed riffle areas of streams or groundwater seepage on shoals in lakes. Fertilization of eggs can involve both adult males and sexually mature precocious males. Mating behaviour typically entails multiple males of several life history types competing aggressively for access to multiple females. This frequently leads to multiple paternity for a given female's offspring. Spawned-out or spent adult salmon (kelts) either return to sea immediately after spawning or remain in fresh water until the following spring. Eggs incubate in the spawning nests over the winter months and hatching usually begins in April. The hatchlings (alevins) remain in the gravel for several weeks living off large yolk sacs. Upon emergence from the gravel in late May – early June, the yolk sac is absorbed and the free-swimming young fish (parr) begin active feeding. Parr rear in fluvial and lacustrine habitats for one to eight years following which they undergo behavioural and physiological transformations and migrate to sea as smolt.

Population sizes and trends

Abundances and trends were highly variable across the 16 DUs, with estimated abundances ranging from estimates of <1000 to 235,874. Although the total Canadian population appears to be relatively stable over the last three generations, this apparent recent stability masks a significant historical decline, regional variability, and a general, although often statistically non-significant decline in abundance for 14 of 16 DUs during the last three generations. The stability of the total Canadian population is driven primarily by estimated increases in abundance in Labrador, although data from this region are relatively limited and there is considerable uncertainty in the resulting abundance estimates and trends. Several of the southern DUs (e.g. DU 16: Outer Bay of Fundy; DU 15: Inner Bay of Fundy; and DU 14: Southern Upland) are at or near their lowest abundance on record. It is also important to point out that several historical analyses in the literature that go back more than four generations show a substantial decline in Canadian abundance. The three-generation analysis completed herein should be considered within this longer-term context.

Threats and limiting factors

Threats to Atlantic Salmon include, but are not limited to, climate change, changes to ocean ecosystems, fishing (commercial, subsistence, recreational, and illegal), dams and obstructions in freshwater, agriculture, urbanization, acidification, aquaculture, and invasive species. The relative contributions of these factors to declines remain unclear and vary among populations. Generally, freshwater threats are less significant in the northern portions of the range. Recent broad-scale declines in marine survival suggest that the most substantial threat(s) to the species are in the marine environment, although in some southern areas, freshwater habitat degradation and fish passage issues are expected to limit population growth if marine survival improves.

Special significance

Atlantic Salmon are contributors to both freshwater and marine ecology, moving nutrients between ecosystems as migrants, and linking energy flow as prey and as predators within ecosystems. They are traditionally used by (i) over 49 First Nations and Aboriginal organizations, (ii) commercial fisheries and (iii) recreational fisheries. They are also the subjects of local art, science and education, and symbols of heritage and health to peoples of Canada.

Existing protection, status, and ranks

The Atlantic Salmon is currently designated or ranked with several international and national bodies. In the United States of America, populations in Maine have *Endangered* status under the *U.S. Endangered Species Act*. In April 2006, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the Inner Bay of Fundy population as *Endangered* and the Lake Ontario population as *Extirpated*. The Atlantic Salmon, Inner Bay of Fundy population is currently listed as *Endangered* under Canada's *Species at Risk Act* (SARA).

Aboriginal traditional knowledge

Aboriginal traditional knowledge (ATK) is considered a critical component for status assessments for endangered wildlife (COSEWIC). Atlantic Salmon, in particular, is a species for which considerable ATK exists. COSEWIC's ATK Subcommittee initiated work with Aboriginal communities in eastern Canada to gather ATK for the COSEWIC Status Report on Atlantic Salmon in 2008. The Aboriginal communities indicated, through the ATK Subcommittee members, that ATK was available and expressed a willingness to share the information. However, challenges arose in developing a satisfactory approach for the collection of this ATK. As such, ATK is not available at this time for use in the COSEWIC Status Report for this species. The ATK Subcommittee and COSEWIC will continue to work on gathering ATK on Atlantic Salmon for inclusion in a future report.

TECHNICAL SUMMARY - Nunavik population (DU1)

Salmo salar	
Atlantic Salmon	Saumon atlantique
Nunavik population	Population du Nunavik
Range of Occurrence in Canada:	Northern Quebec and Labrador / Atlantic Ocean and Hudson Bay

Demographic Information

Generation time (average age of parents in the population)	6.1 yrs
Estimated percent decrease in total number of mature individuals in 2007 versus 1993 (3 generations)	Data deficient, increasing trend in CPUE data
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	N/A
Are the causes of the decline understood?	N/A
Have the causes of the decline ceased?	N/A
Suspected trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	Data deficient
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Suspected trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IAO)	≥5216 km^2
Suspected trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	5 known populations
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Trend in area of habitat	Stable

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
	-
Total	-

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Possible threats include recreational and aboriginal fisheries.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Nearby Labrador populations are increasing.	
Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Unknown

Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Data Deficient (Nov 2010)

Status and Reasons for Designation

Status: Data Deficient	**Alpha-numeric code:** Not applicable
Reasons for designation: This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and several years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population, which breeds in rivers flowing into Ungava Bay and eastern Hudson Bay, is the northernmost population of the species in North America, and the westernmost population of the entire species. It is separated by approximately 650 km from the nearest population to the south. Little is known about abundance trends in this population, although limited catch per unit effort data suggest increased abundance in recent years.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable.
Criterion D (Very Small Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - Labrador population (DU2)

Salmo salar

Atlantic Salmon	Saumon atlantique
Labrador population	Population du Labrador

Range of Occurrence in Canada: Labrador, Quebec / Atlantic Ocean

Demographic Information

Generation time (average age of parents in the population)	6.3 yrs
Estimated percent increase in total number of mature individuals in 2008 versus 1993 (3 generations)	380
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	N/A
Are the causes of the decline understood?	N/A
Have the causes of the decline ceased?	N/A
Observed trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Observed trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IAO)	>2,000 km^2
Observed trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	91 known rivers
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Stable

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
	235,874 (151,049 – 307,731)
Total	235,874 (151,049 – 307,731)

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Potential threats include recreational and Aboriginal fisheries, mining and hydroelectric development.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Nearby Newfoundland populations are stable or increasing.	
Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Not at Risk (Nov 2010)

Status and Reasons for Designation

Status: Not at Risk	**Alpha-numeric code:** Not applicable
Reasons for designation: This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and several years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers along the Atlantic coast of Labrador and southwest along the Quebec coast to the Napetipi River (inclusive). Freshwater habitats remain largely pristine. Abundance data are not available for most rivers; however, for rivers for which data are available, the number of mature individuals appears to have increased by about 380% over the last 3 generations.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable.
Criterion D (Very Small Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - Northeast Newfoundland population (DU3)

Salmo salar
Atlantic Salmon — Saumon atlantique
Northeast Newfoundland population — Population du nord-est de Terre-Neuve
Range of Occurrence in Canada: Newfoundland/Atlantic Ocean

Demographic Information

Generation time (average age of parents in the population)	4.2 yrs
Estimated percent decline in total number of mature individuals in 2007 versus 1993 (3 generations)	10
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	N/A
Are the causes of the decline understood?	N/A
Have the causes of the decline ceased?	N/A
Observed trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Observed trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IAO)	>2,000 km^2
Observed trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	127 known rivers
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Stable

Number of Mature Individuals (in each population)

Population	N Mature Individuals
	80,505 (63,689 – 129,967 (2007)
Total	80,505 (63,689 – 129,967 (2007)

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Recreational and illegal fisheries, poorly understood changes in marine ecosystems resulting in reduced survival during the marine phase of the life history.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Nearby Labrador and Newfoundland populations are stable or increasing, excepting DU 4 (south coast of Newfoundland)	
Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Not at Risk (Nov 2010)

Status and Reasons for Designation

Status: Not at Risk	**Alpha-numeric code:** Not applicable
Reasons for designation: This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers along the northeast coast of Newfoundland, from the northern tip of the island to the southeastern corner of the Avalon Peninsula. Recent abundance data show no clear trends in the number of mature individuals. Since 1992, the negative effects of poor marine survival have been at least partially offset by a near cessation of fishing mortality in coastal fisheries. Illegal fishing is a threat in some rivers.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable.
Criterion D (Very Small Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - South Newfoundland population (DU4)

Salmo salar
Atlantic Salmon — Saumon atlantique
South Newfoundland population — Population du sud de Terre-Neuve
Range of Occurrence in Canada: Newfoundland/Atlantic Ocean

Demographic Information

Generation time (average age of parents in the population)	4.1 yrs
Estimated percent decline in total number of mature individuals in 2007 versus 1993 (3 generations)	36
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	No
Are the causes of the decline understood?	No
Have the causes of the decline ceased?	No
Observed trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Observed trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IAO)	>2,000 km^2
Observed trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	104 known rivers
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Stable

Number of Mature Individuals (in each population)

Population	N Mature Individuals
	21,866 (14,021 – 29,711) (2007)
Total	21,866 (14,021 – 29,711) (2007)

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Recreational and illegal fisheries, commercial fishery in St. Pierre and Miquelon, ecological and genetic interactions with escaped domestic Atlantic Salmon, poorly understood changes in marine ecosystems resulting in reduced survival during the marine phase of the life history.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Nearby Labrador and Newfoundland populations are stable or increasing.	
Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Threatened (Nov 2010)

Status and Reasons for Designation

Status: Threatened	**Alpha-numeric code:** A2b
Reasons for designation: This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers from the southeast tip of the Avalon Peninsula, Mistaken Point, westward along the south coast of Newfoundland to Cape Ray. The numbers of small (one-sea-winter) and large (multi-sea-winter) salmon have both declined over the last 3 generations, about 37% and 26%, respectively, for a net decline of all mature individuals of about 36%. This decline has occurred despite the fact that mortality from commercial fisheries in coastal areas has greatly declined since 1992; this may be due to poor marine survival related to substantial but incompletely understood changes in marine ecosystems. Illegal fishing is a threat in some rivers. The presence of salmon aquaculture in a small section of this area brings some risk of negative effects from interbreeding or adverse ecological interactions with escaped domestic salmon. Genetic heterogeneity among the many small rivers in this area is unusually pronounced, suggesting that rescue among river breeding populations may be somewhat less likely than in other areas.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Threatened, A2b. The decline over the last 3 generations has been 36%.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable.
Criterion D (Very Small Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - Southwest Newfoundland population (DU5)

Salmo salar	
Atlantic Salmon	Saumon atlantique
Southwest Newfoundland population	Population du sud-ouest de Terre-Neuve

Range of Occurrence in Canada: Newfoundland, Quebec/Atlantic Ocean

Demographic Information

Generation time (average age of parents in the population)	5.3 yrs
Estimated percent increase in total number of mature individuals in 2007 versus 1993 (3 generations)	134
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	NA
Are the causes of the decline understood?	NA
Have the causes of the decline ceased?	NA
Observed trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Observed trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IAO)	>2,000 km^2
Observed trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	40 known rivers
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Stable

Number of Mature Individuals (in each population)

Population	N Mature Individuals
	44,566 (2007)
Total	44,566 (2007)

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Recreational and illegal fisheries, clear cut logging near freshwater habitat.

Rescue Effect (immigration from an outside source)

Status of outside population(s)?

Nearby Labrador and Newfoundland populations are stable or increasing, except DU 4 on the south coast of Newfoundland.

Is immigration known?	No

Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Not at Risk (Nov 2010)

Status and Reasons for Designation

Status: Not at Risk	**Alpha-numeric code:** Not applicable

Reasons for designation:

This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers from Cape Ray northwards along the west coast of Newfoundland to approximately 49□24' N, 58□15' W. Both small (one-sea-winter) and large (multi-sea-winter) salmon have increased in number over the last 3 generations, about 132% and 144%, respectively, giving an increase in the total number of mature individuals of about 134%.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable.

Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.

Criterion C (Small and Declining Number of Mature Individuals): Not applicable.

Criterion D (Very Small Population or Restricted Distribution): Not applicable.

Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - Northwest Newfoundland population (DU6)

Salmo salar	
Atlantic Salmon	Saumon atlantique
Northwest Newfoundland population	Population du nord-ouest de Terre-Neuve

Range of Occurrence in Canada: Newfoundland/Atlantic Ocean

Demographic Information

Generation time (average age of parents in the population)	4.5 yrs
Estimated percent decline in total number of mature individuals in 2007 versus 1993 (3 generations)	0
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	NA
Are the causes of the decline understood?	NA
Have the causes of the decline ceased?	NA
Observed trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Observed trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IAO)	>2,000 km^2
Observed trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	34 known rivers
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Stable

Number of Mature Individuals (in each population)

Population	N Mature Individuals
	31,179 (20,061 – 42,296)(2007)
Total	31,179 (20,061 – 42,296)(2007)

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Recreational and illegal fisheries.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Nearby Labrador and Newfoundland populations are stable or increasing, except DU 4 on the south coast of Newfoundland.	
Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Not at Risk (Nov 2010)

Status and Reasons for Designation

Status: Not at Risk	**Alpha-numeric code:** Not applicable
Reasons for designation: This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers along the west coast of Newfoundland from approximately 49□24' N, 58□15' W to the tip of the Great Northern Peninsula. The total number of mature individuals appears to have remained stable over the last 3 generations, and the number of large (multi-sea-winter) salmon appears to have increased by about 42%.	

Applicability of Criteria:

Criterion A (Decline in Total Number of Mature Individuals): Not applicable.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable.
Criterion D (Very Small Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - Quebec Eastern North Shore population (DU7)

Salmo salar	
Atlantic Salmon	Saumon atlantique
Quebec Eastern North Shore population	Population de l'est de la Côte-Nord du Québec
Range of Occurrence in Canada: Quebec/Atlantic Ocean	

Demographic Information

Generation time (average age of parents in the population)	4.7 yrs
Estimated percent decline in total number of mature individuals in 2007 versus 1993 (3 generations)	14
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	N/A
Are the causes of the decline understood?	N/A
Have the causes of the decline ceased?	N/A
Observed trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Observed trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IAO)	≥4428 km^2
Observed trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	20 known rivers
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Stable

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
	4,949
Total	4,949

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Recreational, Aboriginal and illegal fisheries, hydroelectric development, poorly understood changes in marine ecosystems resulting in reduced survival during the marine phase of the life history.

Rescue Effect (immigration from an outside source)

Status of outside population(s)?

Nearby Labrador and Newfoundland populations are stable or increasing, except DU 4 on the south coast of Newfoundland. DUs to the south and west appear to be stable or decreasing (Nova Scotia, and southern New Brunswick DUs)

Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Special Concern (Nov, 2010)

Status and Reasons for Designation

Status: Special Concern	**Alpha-numeric code:** Met criterion for Threatened, C1, but designated Special Concern because of the increase in the number of large fish that have greater reproductive potential.

Reasons for designation:

This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers along the north shore of the St. Lawrence River estuary from the Napetipi River (not inclusive) westward to the Kegaska River (inclusive). This population shows opposing trends in the abundance of small (one-sea-winter) and large (multi-sea-winter) fish. Small salmon have declined 26% over the last 3 generations, whereas large salmon have increased 51% over the same period; pooling the data for both groups suggests a decline of about 14% for all mature individuals considered together. The small size of the population, about 5000 mature fish in 2008, is cause for concern. As is the case for most populations of the species, poor marine survival related to substantial but incompletely understood changes in marine ecosystems is also a concern.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): May meet Threatened C1; population is approximately 5,000 individuals and a combined analysis of small and large salmon suggests a 14% decline over the last 3 generations; however, small and large salmon show opposing trends, and large salmon have increased 51%.
Criterion D (Very Small Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - Quebec Western North Shore population (DU8)

Salmo salar

Atlantic Salmon	Saumon atlantique
Quebec Western North Shore population	Population de l'ouest de la Côte-Nord du Québec

Range of Occurrence in Canada: Quebec/Atlantic Ocean

Demographic Information

Generation time (average age of parents in the population)	4.7 yrs
Estimated percent decline in total number of mature individuals in 2007 versus 1993 (3 generations)	24
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	NA
Are the causes of the decline understood?	NA
Have the causes of the decline ceased?	NA
Observed trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Observed trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IAO)	≥6980 km^2
Observed trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	25 known rivers
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Stable

Number of Mature Individuals (in each population)

Population	N Mature Individuals
	14,821
Total	14,821

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Recreational, Aboriginal and illegal fisheries, hydroelectric development, poorly understood changes in marine ecosystems resulting in reduced survival during the marine phase of the life history.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Nearby Labrador and Newfoundland populations are stable or increasing, except DU 4 on the south coast of Newfoundland. DUs to the south and west appear to be stable or decreasing (Nova Scotia, and southern New Brunswick DUs)	
Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Special Concern (Nov 2010)

Status and Reasons for Designation

Status: Special Concern	**Alpha-numeric code:** Not applicable
Reasons for designation: This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers along the north shore of the St. Lawrence River from the Natashquan River (inclusive) to the Escoumins River in the west (inclusive). Small (one-sea-winter) and large (multi-sea-winter) fish have both declined over the last 3 generations, approximately 34% and 20%, respectively, for a net decline of all mature individuals of about 24%. As is the case for most populations of the species, poor marine survival related to substantial but incompletely understood changes in marine ecosystems is a concern.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable.
Criterion D (Very Small Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - Anticosti Island population (DU9)

Salmo salar	
Atlantic Salmon	Saumon atlantique
Anticosti Island population	Population de l'île d'Anticosti
Range of Occurrence in Canada: Quebec/Atlantic Ocean	

Demographic Information

Generation time (average age of parents in the population)	5 yrs
Estimated percent decline in total number of mature individuals in 2007 versus 1993 (3 generations)	40
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	No
Are the causes of the decline understood?	No
Have the causes of the decline ceased?	Unknown
Observed trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	Unlikely

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Observed trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	Unlikely
Index of area of occupancy (IAO)	2584 km^2
Observed trend in area of occupancy	Unknown
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	25 known rivers
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Stable

Number of Mature Individuals (in each population)

Population	N Mature Individuals
	2,414 (2008)
Total	2,414 (2008)

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Poorly understood changes in marine ecosystems resulting in reduced survival during the marine phase of the life history .

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Nearby Quebec and New Brunswick populations appear to be declining or marginally stable.	
Is immigration known?	No

Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Endangered (Nov 2010)

Status and Reasons for Designation

Status: Endangered	**Alpha-numeric code:** C1
Reasons for designation: This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers on Anticosti Island. Small (one-sea-winter) and large (multi-sea-winter) fish have both declined over 3 generations, approximately 32% and 49%, respectively, for a net decline of all mature individuals of about 40%. The population size is small, about 2,400 individuals in 2008. As is the case for most populations of the species, poor marine survival related to substantial but incompletely understood changes in marine ecosystems is a concern.	

Applicability of criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable but the decline in large salmon (49%) almost meets Endangered A2b, and the overall decline (40%) meets Threatened A2b.
Criterion B (Small Distribution Range and Decline or Fluctuation):Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Meets Endangered, C1; the total number of mature individuals was approximately 2,400 in 2008, and the population has declined about 27% over the last 2 generations.
Criterion D (Very Small Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - Inner St. Lawrence population (DU10)

Salmo salar	
Atlantic Salmon	Saumon atlantique
Inner St. Lawrence population	Population de l'intérieur du Saint-Laurent
Range of Occurrence in Canada: Quebec/Atlantic Ocean	

Demographic Information

Generation time (average age of parents in the population)	3.5 yrs
Estimated percent increase in total number of mature individuals in 2007 versus 1993 (3 generations)	5
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	NA
Are the causes of the decline understood?	NA
Have the causes of the decline ceased?	NA
Observed trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Observed trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IAO)	1552 km^2
Observed trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	9 known rivers
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Stable

Number of Mature Individuals (in each population)

Population	N Mature Individuals
	5,020 (2008)
Total	5,020 (2008)

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Poorly understood changes in marine ecosystems resulting in reduced survival during the marine phase of the life history.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Nearby Quebec and New Brunswick populations appear to be declining or marginally stable.	
Is immigration known?	No

Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Special Concern (Nov 2010)

Status and Reasons for Designation

Status: Special Concern	**Alpha-numeric code:** Not applicable

Reasons for designation:

This species requires rivers or streams that are clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This highly managed population breeds in rivers tributary to the St. Lawrence River upstream from the Escoumins River (not included) on the north shore and the Ouelle River (included) on the south shore. Small (one-sea-winter) and large (multi-sea-winter) fish have both remained approximately stable in abundance over the last 3 generations. The small size of the population, about 5,000 individuals in 2008, is of concern. The rivers in this area are close to the largest urban areas in Quebec and the population has undergone a large historical decline due to loss of habitat. As is the case for most populations of the species, poor marine survival related to substantial but incompletely understood changes in marine ecosystems is a concern.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable.
Criterion D (Very Small Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - Lake Ontario population (DU11)

Salmo salar	
Atlantic Salmon	Saumon atlantique
Lake Ontario population	Population du lac Ontario
Range of Occurrence in Canada: Ontario/Atlantic Ocean	

Demographic Information

Generation time (average age of parents in the population)	4 yrs
Estimated percent decline in total number of mature individuals in 2007 versus 1993 (3 generations)	N/A
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	N/A
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	No
Are the causes of the decline understood?	Yes
Have the causes of the decline ceased?	Unknown
Observed trend in number of populations	N/A
Are there extreme fluctuations in number of mature individuals?	N/A
Are there extreme fluctuations in number of populations?	N/A

Extent and Area Information

Estimated extent of occurrence	N/A
Observed trend in extent of occurrence	Unknown
Are there extreme fluctuations in extent of occurrence?	Unknown
Index of area of occupancy (IAO)	N/A
Observed trend in area of occupancy	Unknown
Are there extreme fluctuations in area of occupancy?	N/A
Is the total population severely fragmented?	N/A
Number of current locations	0
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	Unknown
Trend in [area and/or quality] of habitat	Unknown

Number of Mature Individuals (in each population)

Population	N Mature Individuals
	0
Total	0

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Causes of extinction include deterioration in spawning habitat due to timbering, agriculture, and mills and dams across rivers that prevented access to spawning grounds, in addition to extensive commercial and food fisheries. Thiamine deficiency, associated with preying on alewife, has also been implicated as a barrier to restoration of salmon in this area. Invasive species.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Nearby Quebec, and New Brunswick populations are either declining, or small and marginally stable.	
Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	No
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Extinct (Nov 2010)
Ontario's *Endangered Species Act*: Extirpated

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Extinct	Not applicable

Reasons for designation:

Once a prolific resident throughout the Lake Ontario watershed, there has been no record of this population since 1898. The Lake Ontario population was extinguished through habitat destruction and through over-exploitation by food and commercial fisheries. As the original strain is gone, re-introduction is not possible. Recent attempts to introduce other strains of the species have resulted in some natural reproduction, but no evidence of self-sustaining populations.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable.
Criterion D (Very Small Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - Gaspé-Southern Gulf of St. Lawrence population (DU12)

Salmo salar

Atlantic Salmon	Saumon atlantique
Gaspé-Southern Gulf of St. Lawrence population	Population de la Gaspésie-sud du golfe Saint-Laurent

Range of Occurrence in Canada :Quebec, New Brunswick, Prince-Edward Island, Nova Scotia / Atlantic Ocean

Demographic Information

Generation time (average age of parents in the population)	4.6 yrs
Estimated percent decline in total number of mature individuals in 2007 versus 1993 (3 generations)	28
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	N/A
Are the causes of the decline understood?	N/A
Have the causes of the decline ceased?	N/A
Observed trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Observed trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IAO)	>2,000 km^2
Observed trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	78 known rivers
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Stable

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
	102,263 (2007)
Total	102,263 (2007)

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Recreational and Aboriginal fishing, agriculture, land development, pollution, poorly understood changes in marine ecosystems resulting in reduced survival during the marine phase of the life history, invasive species in freshwater habitats.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Nearby Quebec and New Brunswick populations appear to be declining or marginally stable.	
Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Special Concern (Nov 2010)

Status and Reasons for Designation

Status: Special Concern	**Alpha-numeric code:** Not applicable

Reasons for designation:

This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers from the Ouelle River (excluded) in the western Gaspé Peninsula southward and eastward to the northern tip of Cape Breton. Small (one-sea-winter) and large (multi-sea-winter) fish have both declined over the last 3 generations, approximately 34% and 19%, respectively, for a net decline of all mature individuals of about 28%. This recent 3 generation decline represents a continuation of a decline extending back at least to the 1980s. The number of mature individuals remains over 100,000; however, the majority spawn in a single major river system, the Miramichi, in New Brunswick. Freshwater habitat quality is a concern in some areas, particularly in Prince Edward Island where some remaining populations are maintained by hatchery supplementation. Invasive and illegally introduced species, such as smallmouth bass, are a poorly understood threat in some freshwater habitats. Poor marine survival is related to substantial but incompletely understood changes in marine ecosystems.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable.

Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.

Criterion C (Small and Declining Number of Mature Individuals): Not applicable.

Criterion D (Very Small Population or Restricted Distribution): Not applicable.

Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - Eastern Cape Breton population (DU13)

Salmo salar
Atlantic Salmon
Eastern Cape Breton population
Range of Occurrence in Canada: Nova Scotia / Atlantic Ocean

Saumon atlantique
Population de l'est du Cap-Breton

Demographic Information

Generation time (average age of parents in the population)	5 yrs
Estimated percent decline in total number of mature individuals in 2007 versus 1993 (3 generations)	29 (based on 5 rivers with majority of fish)
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	No
Are the causes of the decline understood?	No
Have the causes of the decline ceased?	No
Observed trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Observed trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IAO)	1684 km^2
Observed trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	30 known rivers
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Stable

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
Only 5 rivers of 30 included in estimate.	1,150 (2008)
Total	1,150 (2008)

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Recreational fishing, habitat loss, poorly understood changes in marine ecosystems resulting in reduced survival during the marine phase of the life history

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Nearby Quebec and New Brunswick populations appear to be declining or marginally stable. Newfoundland DU 5 is increasing, while DU 4 is declining.	
Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Endangered (Nov 2010)

Status and Reasons for Designation

Status: Endangered	**Alpha-numeric code:** C1
Reasons for designation: This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in Cape Breton Island rivers draining into the Atlantic Ocean and Bras d'Or Lakes. The numbers of adults returning to spawn has declined by about 29% over the last 3 generations; moreover, these declines represent continuations of previous declines. The total number of mature individuals in 5 rivers, thought to harbour the majority of the population, was only about 1150 in 2008. There is no likelihood of rescue, as neighbouring regions harbour genetically dissimilar populations, and the population to the south is severely depleted. A current threat is poor marine survival related to substantial but incompletely understood changes in marine ecosystems.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Estimated decline is just below the threshold for Threatened A2b, with a decline of ~29% over the last 3 generations.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Meets Endangered C1. The estimated number of mature individuals in 2008, 1150, is based on only 5 of 30 rivers, but these are thought to account for the majority of the population and therefore the total is thought to be well below 2500. The estimated decline of ~29% over 3 generations corresponds to ~20% over 2 generations.
Criterion D (Very Small Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - Nova Scotia Southern Upland population (DU14)

Salmo salar	
Atlantic Salmon	Saumon atlantique
Nova Scotia Southern Upland population	Population des hautes terres du sud de la Nouvelle-Écosse

Range of Occurrence in Canada: Nova Scotia / Atlantic Ocean

Demographic Information

Generation time (average age of parents in the population)	4 yrs
Estimated percent decline in total number of mature individuals from 1993 to 2007 (3 generations)	61
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	No
Are the causes of the decline understood?	No
Have the causes of the decline ceased?	No
Observed trend in number of populations	Declining
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Observed trend in extent of occurrence	Declining
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IAO)	4280 km^2
Observed trend in area of occupancy	Declining
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	31 known rivers
Trend in number of locations	Declining
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Declining

Number of Mature Individuals (in each population)

Population	N Mature Individuals
Only 4 of the 31 rivers included in estimate.	1,427(2008)
Total	1,427(2008)

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Acidification, habitat loss, recreational fishing, poorly understood changes in marine ecosystems resulting in reduced survival during the marine phase of the life history, ecological and genetic interactions with escaped domestic Atlantic Salmon.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Nearby Nova Scotia and New Brunswick populations appear to be declining.	
Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	No
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Endangered (Nov 2010)

Status and Reasons for Designation

Status: Endangered	Alpha-numeric code: A2bce; C1
Reasons for designation: This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers from northeastern mainland Nova Scotia, along the Atlantic coast and into the Bay of Fundy as far as Cape Split. Small (one-sea-winter) and large (multi-sea-winter) fish have both declined over the last 3 generations by approximately 59% and 74%, respectively, for a net decline of all mature individuals of about 61%. Moreover, these declines represent continuations of greater declines extending far into the past. During the past century, spawning occurred in 63 rivers, but a recent (2008) survey detected juveniles in only 20 of 51 rivers examined. There is no likelihood of rescue, as neighbouring regions harbour severely depleted, genetically dissimilar populations. The population has historically suffered from dams that have impeded spawning migrations and flooded spawning and rearing habitats, and other human influences, such as pollution and logging, that have reduced or degraded freshwater habitats. Acidification of freshwater habitats brought about by acidic precipitation is a major, ongoing threat, as is poor marine survival related to substantial but incompletely understood changes in marine ecosystems. There are a few salmon farms in this area that could lead to negative effects of interbreeding or ecological interactions with escaped domestic salmon.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered A2b,c,e with a decline of 61% in the number of mature individuals over the last 3 generations (12 years), in part due to a decline in the quality of the habitat due to acid precipitation. Breeding has ceased in half of the rivers since the 1980s.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Meets Endangered C1. The number of mature individuals in 2008 was 1427 in 4 rivers thought to include the majority of the population, and therefore is thought to be well below 2500. The population is declining, with a 2-generation decline of ~40%.
Criterion D (Very Small Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - Inner Bay of Fundy population (DU15)

Salmo salar	
Atlantic Salmon	Saumon atlantique
Inner Bay of Fundy population	Population de l'intérieur de la baie de Fundy

Range of Occurrence in Canada: New Brunswick and Nova Scotia / Atlantic Ocean

Demographic Information

Generation time (average age of parents in the population)	4 yrs
Estimated percent decline in total number of mature individuals over the last 3 generations (11 years; to 2002) NOTE: This value was extracted from the 2006 COSEWIC Status Report on the Atlantic Salmon - Inner Bay of Fundy populations. The declining trend did not change in 2003 (Gibson et al. 2004)	> 94% (this is the lowest 90% confidence limit for the healthiest index river)
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	No
Are the causes of the decline understood?	No
Have the causes of the decline ceased?	No
Observed trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Observed trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IAO)	Unknown; actual area of occupancy estimated to be no more than 9 km^2
Observed trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	19 known rivers, less populations
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Declining

Number of Mature Individuals (in each population)

Population	N Mature Individuals
	<100 (2006)
Total	<100 (2006)

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Leading marine considerations: interactions with farmed and hatchery salmon (competition with escapees; parasite and disease epidemics), ecological community shifts (increased predation by native species; lack of forage species), depressed population phenomena (lack of recruits to form effective shoals), environmental shifts (regime shift depressing ocean productivity; altered migration routes leading to depressed survival), fisheries (excessive illegal and/or incidental catch), and the possibility of cumulative interactions among these or more factors. Leading freshwater considerations: interbreeding and competition with escaped farm fish, depressed population phenomena (abnormal behaviour due to low abundance; inbreeding depression), changes in environmental conditions (climate changes leading to premature smolt emigration and decreased freshwater productivity; atmospheric changes increasing ultraviolet radiation; increased contaminant concentrations), historical reduction in habitat quality.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Nearby Nova Scotia and New Brunswick populations appear to declining.	
Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	No
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Endangered (Nov 2010)

Status and Reasons for Designation

Status: Endangered	**Alpha-numeric code:** C2a(i,ii); D1
Reasons for designation: This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population once bred in 32 rivers tributary to the inner Bay of Fundy, from just east of the Saint John River, to the Gaspereau River in Nova Scotia; however, spawning no longer occurs in most rivers. The population, which is thought to have consisted of about 40,000 individuals earlier in the 20th century, is believed to have been fewer than 200 individuals in 2008. Survival through the marine phase of the species' life history is currently extremely poor, and the continued existence of this population depends on a captive rearing program. There is no likelihood of rescue, as neighbouring regions harbour severely depleted, genetically dissimilar populations. The population has historically suffered from dams that have impeded spawning migrations and flooded spawning and rearing habitats, and other human influences, such as pollution and logging, that have reduced or degraded freshwater habitats. Current threats include extremely poor marine survival related to substantial but incompletely understood changes in marine ecosystems, and negative effects of interbreeding or ecological interactions with escaped domestic salmon from fish farms. The rivers used by this population are close to the largest concentration of salmon farms in Atlantic Canada.	

Applicability of Criteria

Criterion A Not applicable, the population declined from about 40,000 earlier in the 20th century to about 250 individuals in 1999.
Criterion B: Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Meets Endangered, C2a(i,ii), based on an inferred continuing decline in numbers of mature individuals, and population fragmentation that has resulted in no population estimated to contain more than 250 individuals and for which at least 95% of mature individuals are contained within a single population (Big Salmon River).
Criterion D (Very Small Population or Restricted Distribution): Meets Endangered, D1 (less than 250 mature individuals). The 2003 fall spawning estimate was less than 100 adults, and the most likely estimate was 50-75.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - Outer Bay of Fundy population (DU16)

Salmo salar	
Atlantic Salmon	Saumon atlantique
Outer Bay of Fundy population	Population de l'extérieur de la baie de Fundy

Range of Occurrence in Canada: New Brunswick / Atlantic Ocean

Demographic Information

Generation time (average age of parents in the population)	4 yrs
Estimated percent decline in total number of mature individuals in 2007 versus 1993 (3 generations)	64
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	No
Are the causes of the decline understood?	No
Have the causes of the decline ceased?	No
Observed trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Observed trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IAO)	6928 km^2
Observed trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	17 known rivers
Trend in number of locations	Declining
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Declining

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
Only 4 rivers included in estimate.	7,584 (2008)
Total	7,584 (2008)

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Recreational fishing, habitat loss, genetic and ecological interactions with escaped domestic Atlantic Salmon, poorly understood changes in marine ecosystems resulting in reduced survival during the marine phase of the life history.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Nearby Nova Scotia and New Brunswick populations appear to declining.

Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Likely
Is there sufficient habitat for immigrants in Canada?	No
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Endangered (Nov 2010)

Status and Reasons for Designation

Status: Endangered	**Alpha-numeric code:** A2b
Reasons for designation: This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers tributary to the New Brunswick side of the Bay of Fundy, from the U.S. border to the Saint John River. Small (one-sea-winter) and large (multi-sea-winter) fish have both declined over the last 3 generations, approximately 57% and 82%, respectively, for a net decline of all mature individuals of about 64%; moreover, these declines represent continuations of greater declines extending far into the past. There is no likelihood of rescue, as neighbouring regions harbour severely depleted, genetically dissimilar populations. The population has historically suffered from dams that have impeded spawning migrations and flooded spawning and rearing habitats, and other human influences, such as pollution and logging, that have reduced or degraded freshwater habitats. Current threats include poor marine survival related to substantial but incompletely understood changes in marine ecosystems, and negative effects of interbreeding or ecological interactions with escaped domestic salmon from fish farms. The rivers used by this population are close to the largest concentration of salmon farms in Atlantic Canada.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered A2b. The 3-generation decline in overall numbers of mature salmon is 64% and the decline in large (multi-seawinter) salmon is 82%
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable.
Criterion D (Very Small Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2010)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment Canada
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The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

on the

Atlantic Salmon
Salmo salar

Nunavik population, Labrador population, Northeast Newfoundland population, South Newfoundland population, Southwest Newfoundland population, Northwest Newfoundland population, Quebec Eastern North Shore population, Quebec Western North Shore population, Anticosti Island population, Inner St. Lawrence population, Lake Ontario population, Gaspé-Southern Gulf of St. Lawrence population, Eastern Cape Breton population, Nova Scotia Southern Upland population, Inner Bay of Fundy population, Outer Bay of Fundy population

in Canada

2010

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WILDLIFE SPECIES INFORMATION

Name and classification

Class: Osteichthyes / Actinopterygii
Order: Salmoniformes
Family: Salmonidae
Latin binomial: *Salmo salar* L.
Designatable Unit: See DU Section
Common species names:
English – Salmon, ouananiche (non-anadromous life history form)
French – Saumon atlantique
Other common names exist for various forms and life history stages of the species (e.g., see Froese and Pauly 2004).

Morphological description[i]

The most complete morphological description of Atlantic Salmon can be found in Scott and Crossman (1973) where it is described as having a 'trout-like' body with an average length of about 18 inches (457 mm), somewhat compressed laterally, with the greatest body depth usually at the dorsal fin origin or slightly posterior to it. The anadromous salmon has a blue-green back, silvery sides and a white belly (Carcao 1986). There are several X-shaped and round spots mostly above the lateral line (Carcao 1986). When a marine salmon re-enters freshwater it loses the silvery guanine coat replacing it with hues of greenish or reddish brown and large spots that are edged with white (Scott and Crossman 1973, Carcao 1986). Juvenile salmon, or parr, display 'parr marks' (pigmented vertical bands), with a single red spot between each parr mark along the lateral line (Scott and Crossman 1973). When parr are ready to migrate to sea, they are known as smolts. At this stage the parr marks are lost and the fish become silvery (Scott and Crossman 1973).

Spatial population structure[ii]

A well-known characteristic of Atlantic Salmon is that mature adults generally return to their natal streams to spawn (recently reviewed in Hendry *et al.* 2004). However, some salmon do stray, spawn successfully, and produce offspring that are capable of surviving to spawn in later years. Analyses of molecular genetic variation can help determine the extent of reproductive isolation among salmon from different locations and hence the potential for adaptive differences to accrue (Waples 1991). Analyses of molecular genetic variation can also help identify highly divergent lineages that may have accumulated substantial genetic differences over long periods of reproductive isolation (Utter *et al.*1993).

A variety of studies of genetic variation within and among Atlantic Salmon populations have been carried out. Most have involved sample collections from several rivers from one or two regions, and a few have included collections from one or two rivers from several or all regions. These studies have all shown some degree of population structuring and genetic differentiation. They also suggest that individual rivers and in some cases even tributaries represent relatively independent demographic units.

The most informative genetic analysis of Atlantic Salmon populations in Quebec, New Brunswick and Labrador is that carried out by Dionne *et al.* (2008). Using a combination of landscape genetics and hierarchical analysis of genetic variance they identified seven regional groups (1: Ungava; 2: Labrador; 3: Lower North Shore; 4: Higher North Shore; 5: Quebec City; 6: Southern Quebec; 7: Anticosti; Figure 1) and showed that genetic variance among rivers within regions (2.02%) was less than variance among regions (2.54%). The extent of genetic differentiation among rivers from different regions was on average double that observed among rivers within any given region, although genetic differences between most pairs of rivers within regions were still statistically significant. Genetic divergence among populations and regions was correlated with coastal distance among rivers and degree of difference in temperature regime. In another study, Dionne *et al.* (2007) found that salmon appear to show some local adaptation in the form of genetic variation in MHC genes that is correlated with latitudinal changes in temperature regimes, which in turn are thought to drive clines in pathogen diversity.

Recent work in insular Newfoundland revealed genetic differentiation within rivers, primarily between anadromous and non-anadromous life history forms, but also among anadromous forms within relatively small watersheds (<1000 km^2) (mean $F_{ST} = 0.015$-0.019, $P < 0.05$) for all pair-wise comparisons) (Adams 2007) (Figure 2). Adams (2007) did pair-wise comparisons of eight rivers in southern Labrador (Eagle River and south) and found a mean F_{ST} of 0.017 ($P < 0.001$). The divergence among rivers seemed to be influenced by river size. Divergence among several subsets of rivers (e.g., Alexis River and proximate rivers) was lower than expected, with no significant differences in multiple pair-wise comparisons. An examination of within-river structure by Dionne *et al.* (2009a) suggested significant within-river population structure. However, the degree was highly variable among rivers.

The influences of temporal variation, effective population size, life history variation, and local adaptation on gene flow among rivers and regions of Newfoundland and Labrador have also been examined (Palstra *et al.* 2007) (Figure 3). These authors demonstrated temporal stability across multiple generations and also suggested that metapopulation dynamics might be important in maintaining stability in smaller populations. Palstra *et al.* (2007) also suggested that the magnitude and directionality of gene flow among populations is variable and may even reverse direction when moving from contemporary to evolutionary time scales. Their work also suggested some level of correlation in life history and demographic attributes, and genetic population structure.

Verspoor (2005) reported that "variation among loci was highly heterogeneous at all polymorphic loci" for samples taken across Atlantic Canada, but did not provide information on specific pair-wise comparisons. King *et al.* (2001), in a hierarchical gene diversity analysis, partitioned variance among provinces or states, among rivers within provinces or states, and within rivers. The proportion of variance associated with among-river comparisons was 2.99% (within province or state), as opposed to 5.28% among countries in Europe. Pair-wise tests for significant differences among populations (rivers) were not provided. Bootstrap analyses were used by McConnell *et al.* (1997) to test for pair-wise differences among sample collections from different rivers for three different genetic distance measures, Roger's modified genetic distance, allele sharing genetic distance, and Goldstein's (δμ)2 distance. All pair-wise estimates of Roger's distance and nearly all estimates of allele sharing genetic distance were significant, but very few estimates of Goldstein's $(\delta\mu)^2$ distance were significant; most of these involved the Gander River, Newfoundland. Again, only a few rivers in each region were surveyed in this study.

Verspoor (2005) presented the most geographically comprehensive study published to date, and included multiple river populations from multiple regions (Newfoundland and Labrador, Quebec, Gulf, and Maritimes). In this study, variation was surveyed at 23 allozyme loci, of which 15 were informative (genetically variable). Multi-Dimensional Scaling analyses (Figure 4), and neighbour joining trees (Figure 5), both based on Nei's DA distance, suggested the presence of six large-scale groupings of Atlantic Salmon in Eastern Canada: Labrador and Ungava, Gulf of Saint Lawrence, Newfoundland (excluding Gulf rivers), Atlantic Shore/Southern Upland of Nova Scotia, inner Bay of Fundy (iBoF), and outer Bay of Fundy (oBoF). Labrador and Ungava rivers grouped together, as did salmon from Newfoundland, excluding those from rivers that drain into the Gulf of Saint Lawrence. Generally speaking, salmon from the Atlantic coast of Nova Scotia (Southern Upland) clustered together and were distinct from all other samples analyzed, as were salmon from the inner Bay of Fundy. Many of the regional groupings identified above have also been reported in other studies, involving different molecular markers. Verspoor *et al.* (2002) identified an mtDNA haplotype in multiple inner Bay of Fundy rivers, at moderate to high frequency, that was completely absent in outer Bay of Fundy samples. In a recently expanded, though not yet published analysis of mtDNA in Atlantic salmon from Eastern Canada, Verspoor also noted the complete absence of the inner Bay mtDNA haplotype in 16 rivers of the Southern Upland. Verspoor *et al.* (2002) also identified an mtDNA haplotype in nearly all surveyed Southern Upland rivers that was absent in samples from all other surveyed salmon populations in Eastern Canada.

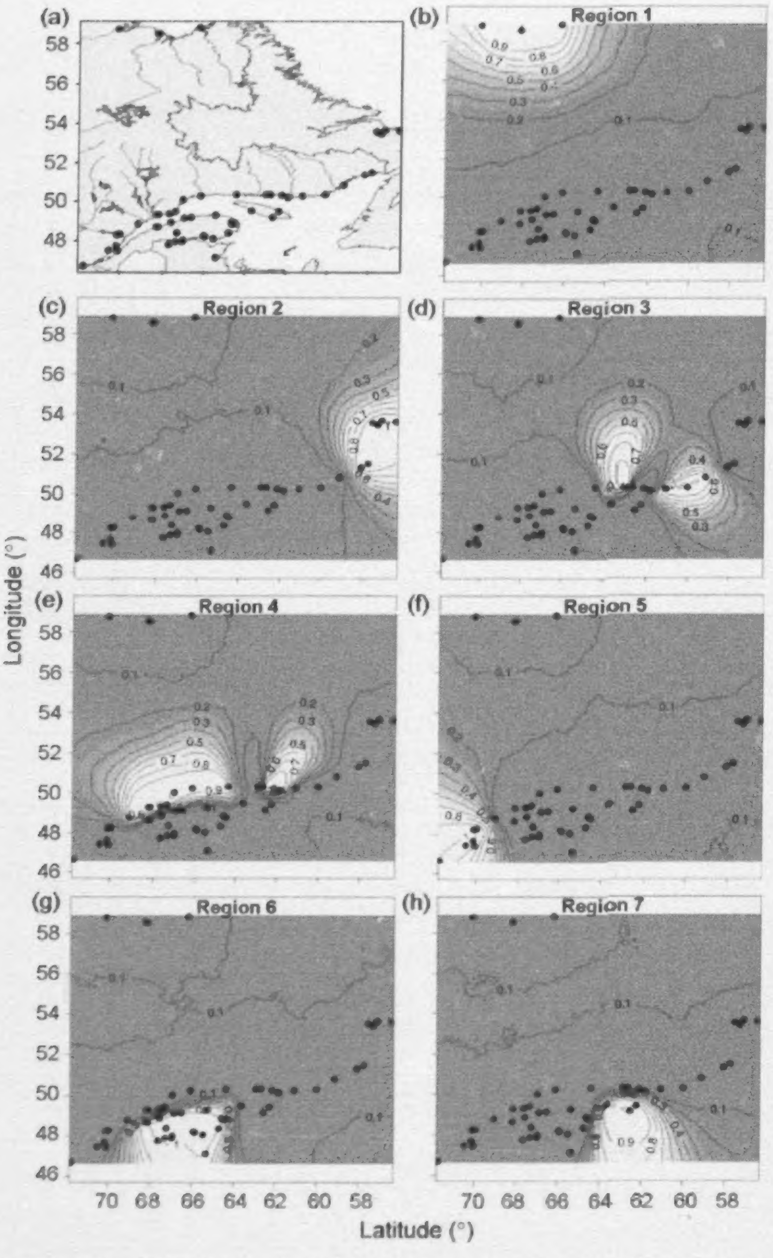
Spidle *et al.* (2003) and King *et al.* (2001), in surveys of variation in largely overlapping suites of microsatellites, found the inner Bay and Southern Upland populations included in the analysis to be highly distinct from all other populations analyzed (Figure 6). In a UPGMA tree of microsatellite-based pair-wise estimates of Roger's genetic distance (McConnell *et al.* 1997), the 10 Southern Upland populations all clustered together, as did Stewiacke and St. Croix, NS populations (two inner Bay populations). The Gaspereau River again grouped separately from all other rivers, a likely result of a population bottleneck and rapid recent genetic drift.

Substantial evidence also exists for the distinctiveness of Newfoundland populations relative to other North American salmon populations in microsatellite allele (Spidle *et al.* 2003, King *et al.* 2001) and mtDNA haplotype (King *et al.* 2000) frequencies. Particularly notable are the presence of 'European' haplotypes in northeast coast Newfoundland populations, suggesting some post-glacial colonization of this area from European refugial populations.

Few surveys included samples from Labrador, and even fewer considered samples from Ungava (but see Fontaine *et al.* 1997 and Dionne *et al.* 2008). King *et al.* (2001) and Spidle *et al.* (2003) identified the Labrador populations as highly distinct from other populations. Adams (2007) compared samples from eight rivers in southern Labrador to four rivers from northeastern Newfoundland and found evidence of divergence at 10 microsatellite loci ($F_{ST} = 0.021$). The divergence, however, was similar to comparisons between insular Newfoundland rivers.

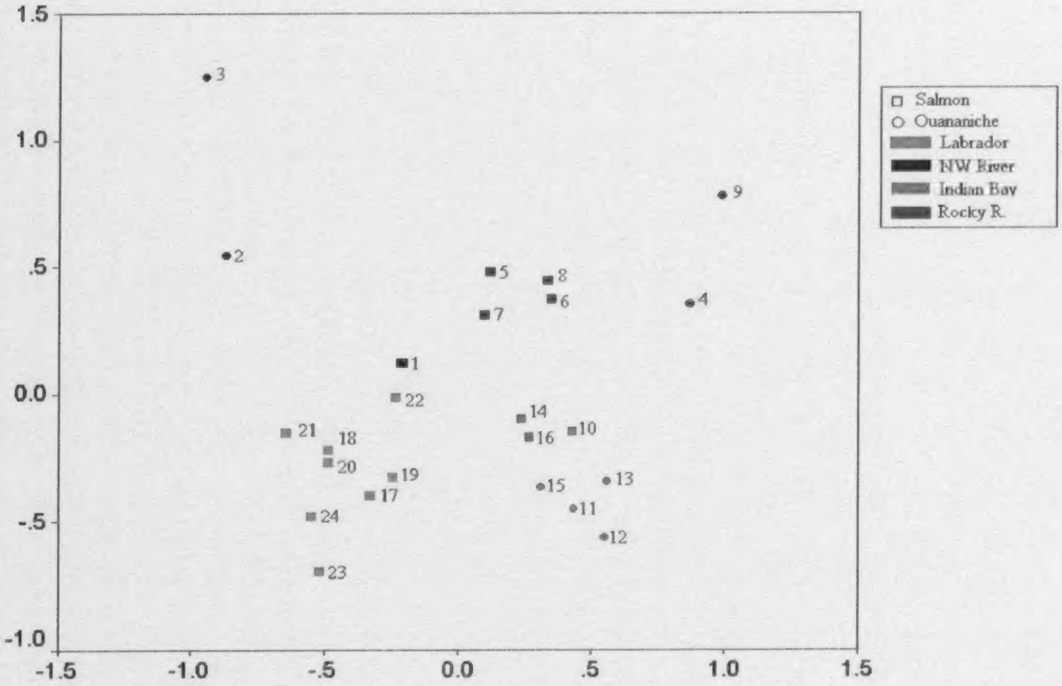
Non-genetic data support much of the broad-scale population structure inferred from the genetic data. For example, Chaput *et al.* (2006a) examined variation in life histories across the Canadian range of the species, including smolt age, small and large salmon proportions in returns, sea-age at maturity, proportion of small and large females, and fork length of small and large fish. This study was able to demonstrate clusters of populations with similar life history variation. For example, one clear differentiation was the dominance of grilse (one-sea-winter age at maturity) spawners in insular Newfoundland versus MSW-dominated populations in other areas. Populations also clustered based on smolt age and at-sea growth. Schaffer and Elson (1975) and Hutchings and Jones (1998) also demonstrated clear divergence in sea-age at maturity and size across regions.

Morphology and meristics have also been used to define salmon stocks in the North Atlantic. Claytor and MacCrimmon (1988) and Claytor *et al.* (1991) were able to show regional differentiation based on morphology, but meristic metrics were less successful. They concluded that insular Newfoundland, Labrador/Quebec, and the Maritime populations represented three very distinct regions. They also suggested, but with less certainty, that sub-structuring was likely in the Maritime regions.



(a)
(b)
Region 1
(c)
Region 2
(d)
Region 3
(e)
Region 4
(f)
Region 5
(g)
Region 6
(h)
Region 7
58
56
54
52
50
48
46
Longitude (°)
70
68
66
64
62
60
58
Latitude (°)
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9

Figure 1. Posterior probabilities for each Atlantic Salmon river-specific population belonging to each of the seven regional groups in Quebec and Labrador identified by landscape genetics analysis. The white area denotes a 90-100% probability that populations belong to their respective regional group. (a) Map of the river-specific populations included in the analysis. (b) Regional group 1: 'Ungava' (3 Rivers); (c) Regional group 2: 'Labrador' (7 rivers); (d) Regional group 3: 'Lower North Shore' 4 rivers); (e) Regional group 4: 'Higher North Shore' (10 rivers); (f) Regional group 5: 'Quebec City' (6 rivers); (g) Regional group 6: 'Southern Quebec' (18 rivers); (h) Regional group 7: 'Anticosti' (3 rivers) (Dionne *et al.* 2008).



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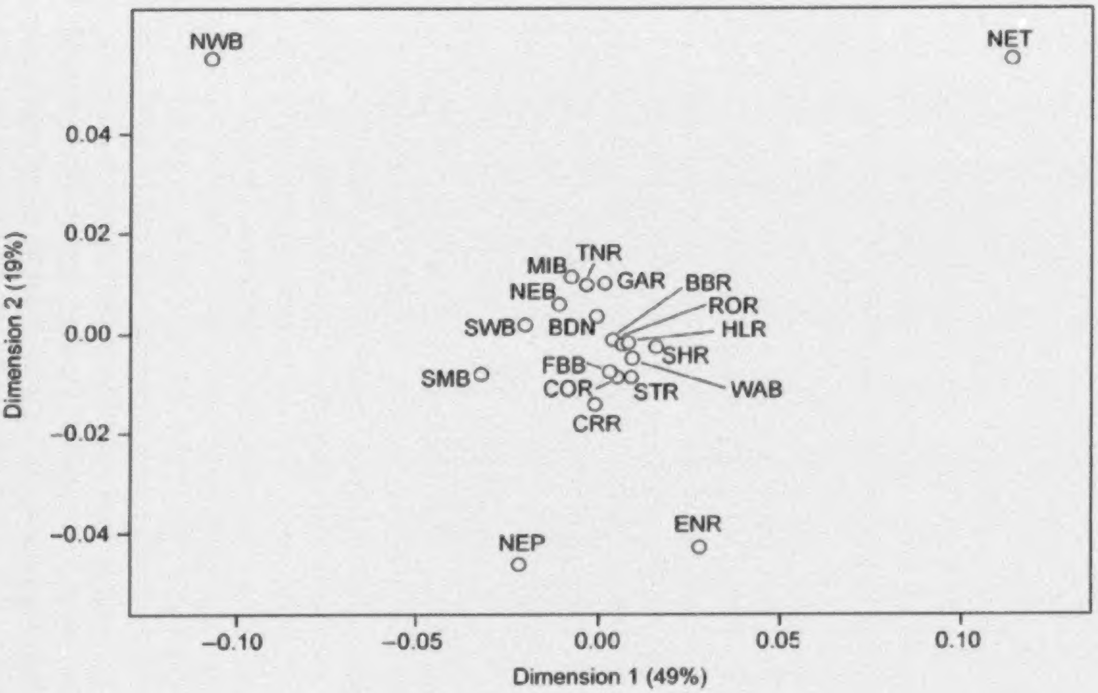

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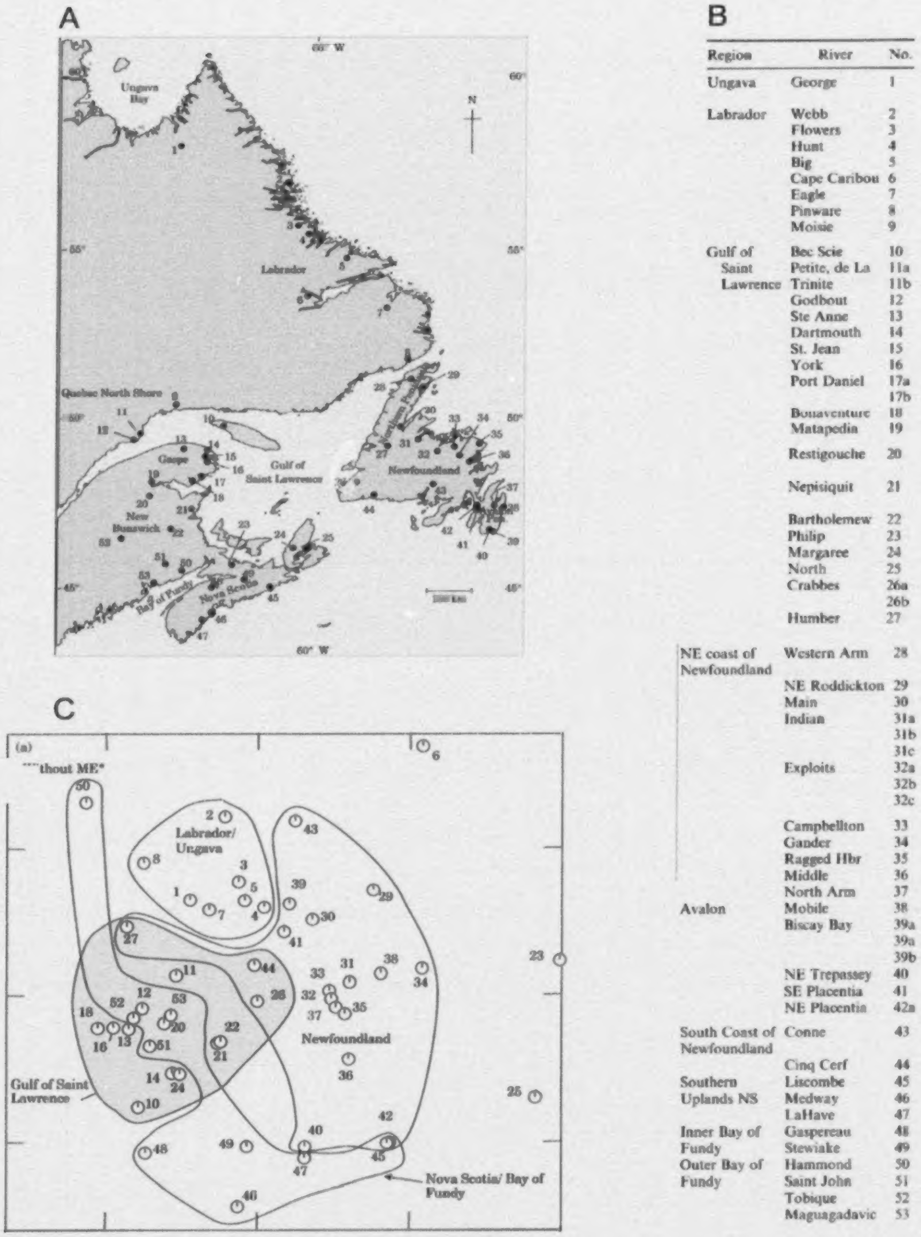

A
60° W
Ungava Bay
N
55°
Labrador
Quebec North Shore
Gaspe
Gulf of Saint Lawrence
New Brunswick
Newfoundland
Bay of Fundy
Nova Scotia
45°
C
(a)
Labrador/ Ungava
Newfoundland
Gulf of Saint Lawrence
Nova Scotia/ Bay of Fundy

B

Region	River	No.
Ungava	George	1
Labrador	Webb	2
	Flowers	3
	Hunt	4
	Big	5
	Cape Caribou	6
	Eagle	7
	Pinware	8
	Moisie	9
Gulf of Saint Lawrence	Bec Scie	10
	Petite, de La	11a
	Trinite	11b
	Godbout	12
	Ste Anne	13
	Dartmouth	14
	St. Jean	15
	York	16
	Port Daniel	17a
		17b
	Bonaventure	18
	Matapedia	19
	Restigouche	20
	Nepisiquit	21
	Bartholemew	22
	Philip	23
	Margaree	24
	North	25
	Crabbes	26a
		26b
	Humber	27
NE coast of Newfoundland	Western Arm	28
	NE Roddickton	29
	Main	30
	Indian	31a
		31b
		31c
	Exploits	32a
		32b
		32c
	Campbellton	33
	Gander	34
	Ragged Hbr	35
	Middle	36
	North Arm	37
Avalon	Mobile	38
	Biscay Bay	39a
		39a
		39b
	NE Trepassey	40
	SE Placentia	41
	NE Placentia	42a
South Coast of Newfoundland	Conne	43
	Cinq Cerf	44
Southern Uplands NS	Liscombe	45
	Medway	46
	LaHave	47
Inner Bay of Fundy	Gaspereau	48
	Stewiake	49
Outer Bay of Fundy	Hammond	50
	Saint John	51
	Tobique	52
	Maguagadavic	53

Figure 4. Allozyme variation in Canadian Atlantic Salmon populations. A, map showing locations of 53 rivers that were included in a multilocus allozyme study (Verspoor 2005). B, list of rivers. C, multidimensional scaling plot for 48 rivers based on Nei's DA genetic distance. Large-scale groupings of Atlantic Salmon populations proposed by Verspoor (2005) are indicated. Modified from Verspoor (2005).

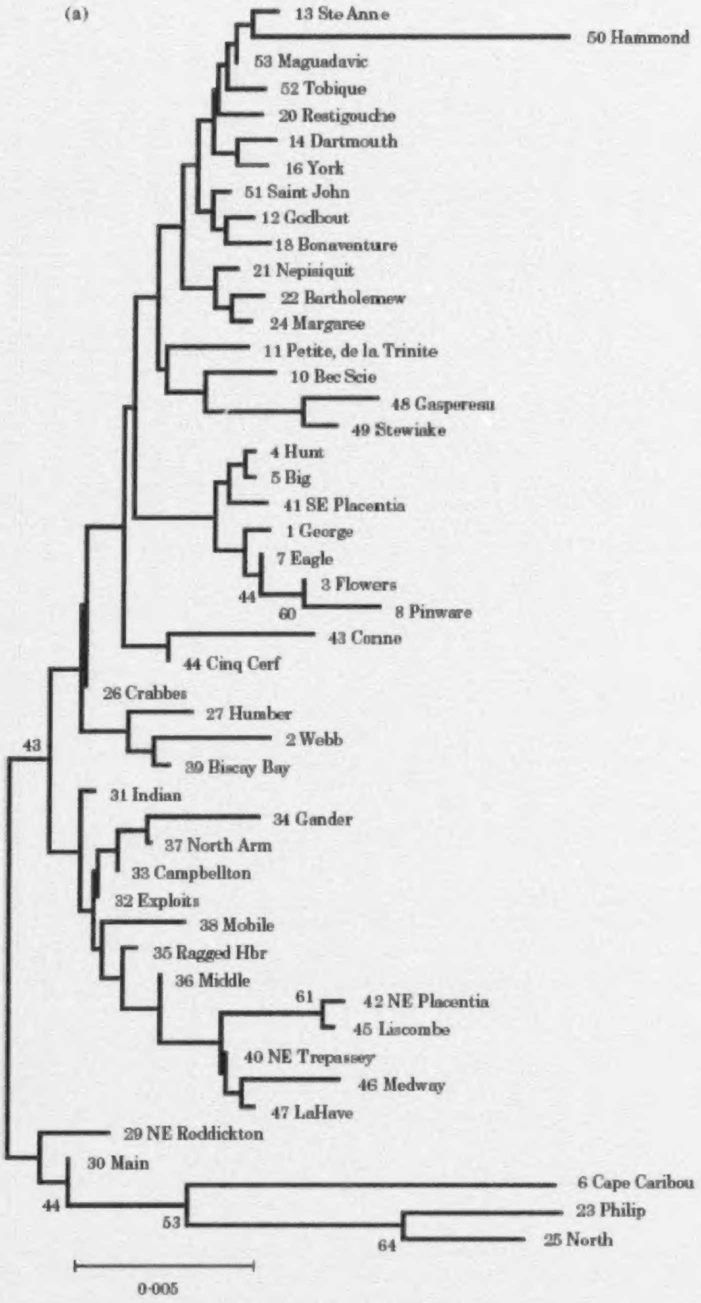

(a)
13 Ste Anne
50 Hammond
53 Maguadavic
52 Tobique
20 Restigouche
14 Dartmouth
16 York
51 Saint John
12 Godbout
18 Bonaventure
21 Nepisiquit
22 Bartholemew
24 Margaree
11 Petite, de la Trinite
10 Bec Scie
48 Gaspereau
49 Stewiake
4 Hunt
5 Big
41 SE Placentia
1 George
7 Eagle
3 Flowers
44
60
8 Pinware
43 Conne
44 Cinq Cerf
26 Crabbes
27 Humber
43
2 Webb
39 Biscay Bay
31 Indian
34 Gander
37 North Arm
33 Campbellton
32 Exploits
38 Mobile
35 Ragged Hbr
36 Middle
61
42 NE Placentia
45 Liscombe
40 NE Trepassey
46 Medway
47 LaHave
29 NE Roddickton
30 Main
6 Cape Caribou
44
23 Philip
53
25 North
64
0·005

Figure 5. Neighbour-joining dendrogram based on allozyme data using Nei's genetic distance, for 48 Canadian rivers (Verspoor 2005). See Figure 4 for regional groupings, river numbers are congruent.

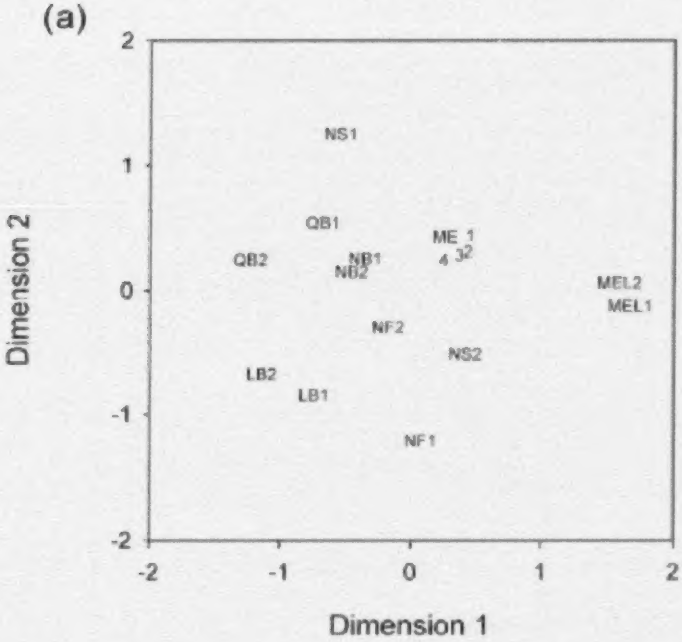


Figure 6. Multidimensional scaling plot based on microsatellite data for 16 rivers in Canada (Newfoundland (NF), Quebec (QB), Nova Scotia (NS), New Brunswick (NB) and Maine (ME, MEL)). NF1 Conne, NF2 Gander, ME1,2,3,4 (Maine), NS1 Stewiacke, NS2 Gold, QB1 St. Jean, QB2 Saguenay, NB1 Naswaak, NB2 Miramichi, MEL1,2 (Maine Landlocked), LB1 Sandhill, LB2 Michaels (King *et al.* 2001).

DESIGNATABLE UNITS

COSEWIC guidelines state that "a population or group of populations may be recognized as a DU if it has attributes that make it "discrete" and evolutionarily "significant" relative to other populations". Evidence of discreteness can include "inherited traits (e.g. morphology, life history, behaviour) and/or neutral genetic markers (e.g. allozymes, DNA microsatellites..." as well as large disjunctions between populations, and occupation of different eco-geographic regions.

The well-known homing behaviour of Atlantic Salmon, as well as the morphological, life history, behavioural and molecular genetic data cited above, all indicate that the criterion of 'discreteness' is routinely satisfied at the level of rivers (as representative of discrete breeding populations), and indeed in some cases may be met at the level of tributaries within river drainages. Since Atlantic Salmon are believed to have spawned in ~700 rivers in Canada, this could suggest the possibility of a huge number of DUs; however, the second criterion of 'evolutionary significance' needs to be considered as well. The COSEWIC guidelines suggest four criteria for 'significance', three of which may be applicable to Atlantic Salmon.

The first 'significance' criterion is "evidence that the discrete population or group of populations differs markedly from others in genetic characteristics thought to reflect relatively deep intraspecific phylogenetic divergence". This criterion is met for Atlantic Salmon at the ocean basin scale: a variety of molecular genetic data indicate that North American populations of Atlantic Salmon are divergent from European populations (*e.g.*, King *et al.* 2000, 2001, Verspoor 2005). This deep split between eastern and western Atlantic Salmon populations is, however, of little relevance for assigning DUs of Canadian populations, except perhaps in one case. Atlantic Salmon populations in northeastern Newfoundland (DU 3, below) show the presence of 'European' mtDNA genotypes that do not naturally occur in any salmon populations to the south, suggesting that post-glacial colonization of this part of Newfoundland was in part from Europe (King *et al.* 2000). Apart from the mtDNA data for DU 3, there is little evidence of deep genetic distinctions (in neutral markers) among groups of Atlantic Salmon populations in Canada. The lack of evidence may in part be due to the relative lack of geographically comprehensive studies of genetic variation among Atlantic Salmon populations in Canada. Most studies have only sampled a portion of the Canadian range. The most geographically extensive genetic study to date is that of Verspoor (2005), which examined allozyme variation in 53 populations spanning most of the Canadian range. Verspoor (2005) suggested that the allozyme data supported the presence of six major population groups of salmon; however, the distinctions between groups were not large, and were not supported by statistical criteria (Figures 4 and 5).

The second 'significance' criterion of relevance is "persistence of the discrete population or group of populations in an ecological setting unusual or unique to the wildlife species, such that it is likely or known to have given rise to local adaptations". As for discreteness, there is abundant evidence of varying local adaptations in Atlantic Salmon. Since Atlantic Salmon spend the first one to several years of their life in fresh water, many adaptations reflect local or regional variation in freshwater habitat attributes including, but not limited to, temperature, length of growing season, and pH. Other potentially adaptive variation includes variation among populations in the proportions of populations maturing as precocious male parr, or as one-sea-winter (1SW) or multi-sea-winter (MSW) salmon. Additional adaptive variation may include varying migration routes to distant ocean feeding grounds. At the molecular level, Dionne *et al.* (2007) found evidence of latitudinal clines in genetic variation at MHC loci, which they interpreted as evidence of adaptation to latitudinally varying assemblages of parasites.

Past attempts to artificially enhance local salmon populations by stocking them with hatchery-bred salmon derived from other populations have provided indirect evidence of local adaptation. For example, Ritter (1975) showed that the performance of hatchery-bred Atlantic Salmon stocked as smolts in rivers varied dramatically depending on the geographic distance between the 'source' populations (which were in the Gulf of St. Lawrence) and the 'destination' rivers in which they were stocked. Catches of salmon, both in distant marine fisheries and in local fisheries in or around the stocked river itself, were much lower when the salmon were stocked in rivers distant from the source rivers than when they were stocked in nearby rivers (Figure 7). Ritter (1975) concluded that the salmon did poorly when stocked outside their home region because of a mismatch between their adaptations and the locations in which they were stocked. Similarly, two reports on the status of Atlantic Salmon populations in Maine concluded that years of stocking of Maine rivers from several Canadian populations had not significantly eroded the genetic distinctiveness of a number of Atlantic Salmon populations in Maine, presumably because the stocked salmon were maladapted to local conditions (National Research Council 2002, 2004).

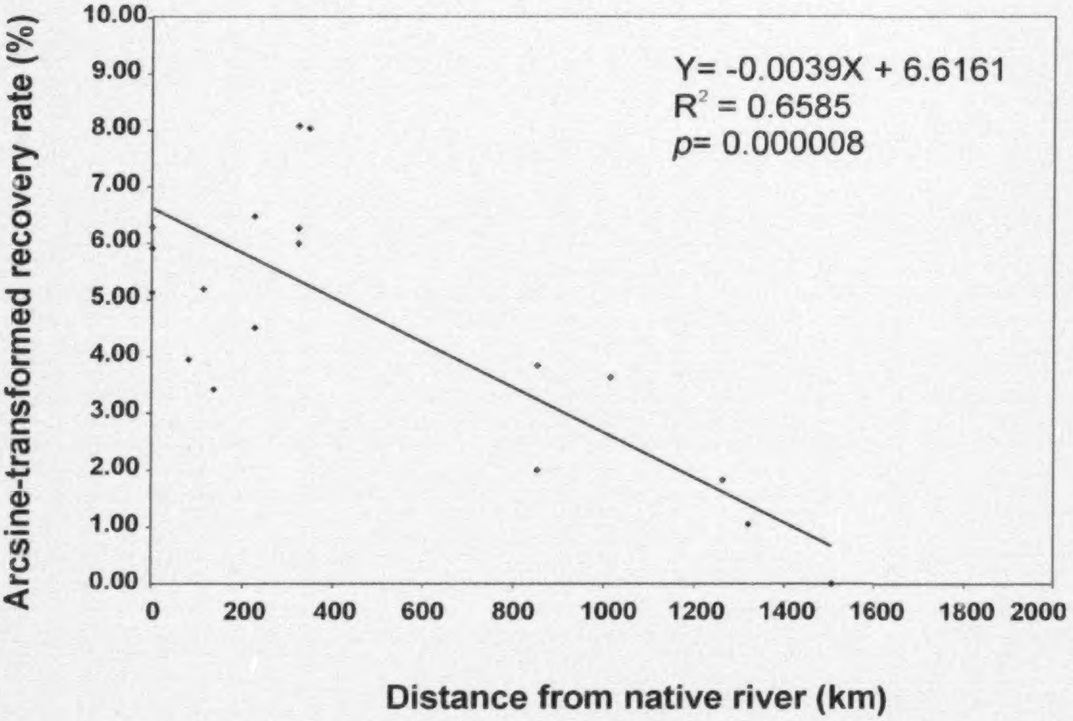


Figure 7. Recovery rates for stocked Atlantic Salmon versus distance from the native river. Shown are total recovery rates (both distant water ocean fisheries and in- or near-river terminal fisheries) for Atlantic Salmon stocked as smolts in rivers at varying distances from their native river. The results for distant water ocean fisheries and in- or near-river terminal fisheries are similar when analyzed separately (results not shown). Analysis of data from Ritter (1975) courtesy of C. Havie and P. O'Reilly.

The various lines of evidence cited above all indicate that Atlantic Salmon populations are locally adapted, and that they are therefore not ecologically exchangeable at some spatial scales. The difficulty lies in determining what those spatial scales are, or where differences among populations become great enough to merit status as DUs. Although it does not directly address this issue, the third COSEWIC 'significance criterion of relevance to Atlantic Salmon may be of some help. It refers to "evidence that the loss of the discrete population or group of populations would result in an extensive gap in the range of the wildlife species in Canada". Many of the DUs proposed below represent a sizable fraction of the species' range in Canada, as well as showing some attributes of distinctiveness, and those DUs that are relatively small in area tend to have particularly strong evidence of genetic or ecological distinctiveness. It can be argued that the loss of any one of these units would represent a substantial loss of diversity within Atlantic Salmon in Canada.

Among the factors considered were genetic divergence, life history and morphometric variation, and geographic separation. As noted above, neutral genetic markers alone are not sufficient to define DUs, but they can, however, provide information on relative levels of gene flow among populations. Life history variation that was considered included data such as smolt age, sea age at maturity, run timing, migratory route, proportion female, and mean length at various life stages. Geographic separation was generally considered significant for major divisions such as insular Newfoundland versus mainland Canada, or north and south of the Gulf of St. Lawrence.

DU boundaries in Quebec and Labrador were guided in large part by the results of the extensive study conducted by Dionne *et al.* (2008). Using data from 13 microsatellite loci on salmon from 51 rivers, they used a combination of hierarchical and landscape genetic analyses in an effort to disentangle the relative influences of a range of factors (temperature, latitude, 'coastal distance' [from the southernmost population, the Miramichi], 'migration tactic' [shorter migrating 1SW vs. longer migrating MSW salmon], an index of the 'difficulty of upstream migration', and stocking history) on genetic structure of Atlantic Salmon populations in the Quebec-Labrador region. They identified seven regional groupings of Atlantic Salmon, which have been adopted as DUs. Temperature and distance, both between rivers and from the southern boundary of the study area, emerged as key determinants of the genetic structure of Atlantic Salmon populations. The influence of distance from the south was suggested to be the "historical footprint of the North American colonization process" from a glacial refugium southward of the contemporary range. In other words, historical effects dating from early post-glacial colonization remain evident in contemporary population structure. Importantly, evidence of dispersal was detected, both within and among population groupings, but genetic differentiation between rivers was lower for dispersal within population groups than it was for similar levels of dispersal between population groups. This observation led the authors to hypothesize that gene flow (as opposed to dispersal) between population groups is constrained by differing thermal regimes which promote local adaptation within groups.

The Department of Fisheries and Oceans (DFO) has previously defined 28 Conservation Units (CUs) for Atlantic Salmon (DFO and MRNF 2008; Figure 8); whereas, 16 DUs are recognized (Figure 9). Despite the difference in the numbers of DUs and CUs, and the fact that the DUs were developed independently, the 16 DUs share many features with the 28 CUs. The majority of boundaries between DUs coincide with CU boundaries. Nine DUs (1, 3, 5, 6, 9, 11, 14, 15, 16) correspond to (differently numbered) CUs. Two DUs (4, 13) each comprise two CUs. One DU (2) combines two very large and one very small CU in Labrador, and unlike the CUs, extends into Quebec. Three DUs within Quebec have different boundaries than the CUs in the same area and together include five CUs and parts of two others. DU 12 (Gaspé-

Southern Gulf of St. Lawrence) comprises all of six CUs, and part of another. The similarities between DUs and CUs reflects the similarity of the definition used for CUs ("groups of individuals likely exhibiting unique adaptations that are largely reproductively isolated from other groups, and that may represent an important component of a species' biodiversity"; DFO and MRNF 2008) to the criteria used by COSEWIC to recognize DUs. The differences largely reflect two factors: the availability of newer data, particularly those in Dionne *et al.* (2008), which formed the basis for decisions about DU structure in the Quebec-Labrador region, and an operational strategy of lumping CUs within DUs when evidence supporting splitting was judged to be weak. The relatively large DU 2 (Labrador) and DU 12 (Gaspé – Southern Gulf of St. Lawrence) reflect this strategy of lumping CUs in the absence of strong data for splitting. The structure for these large DUs may require refinement in the future as more data become available. In the following descriptions, DUs are cross-referenced with DFO CUs and Salmon Fishing Areas, and Quebec Fishing Zones. A tabular comparison of DU characteristics is presented in Table 1.

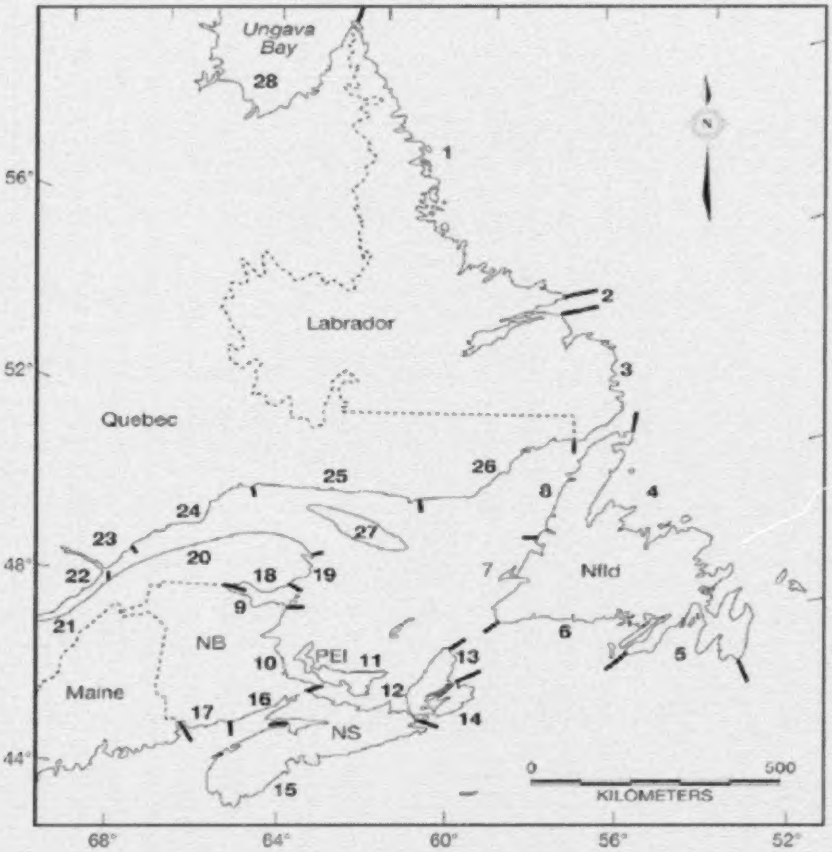


Figure 8. Conservation Units (CUs) proposed by the Department of Fisheries and Oceans for Atlantic Salmon (DFO and MRNF 2008).

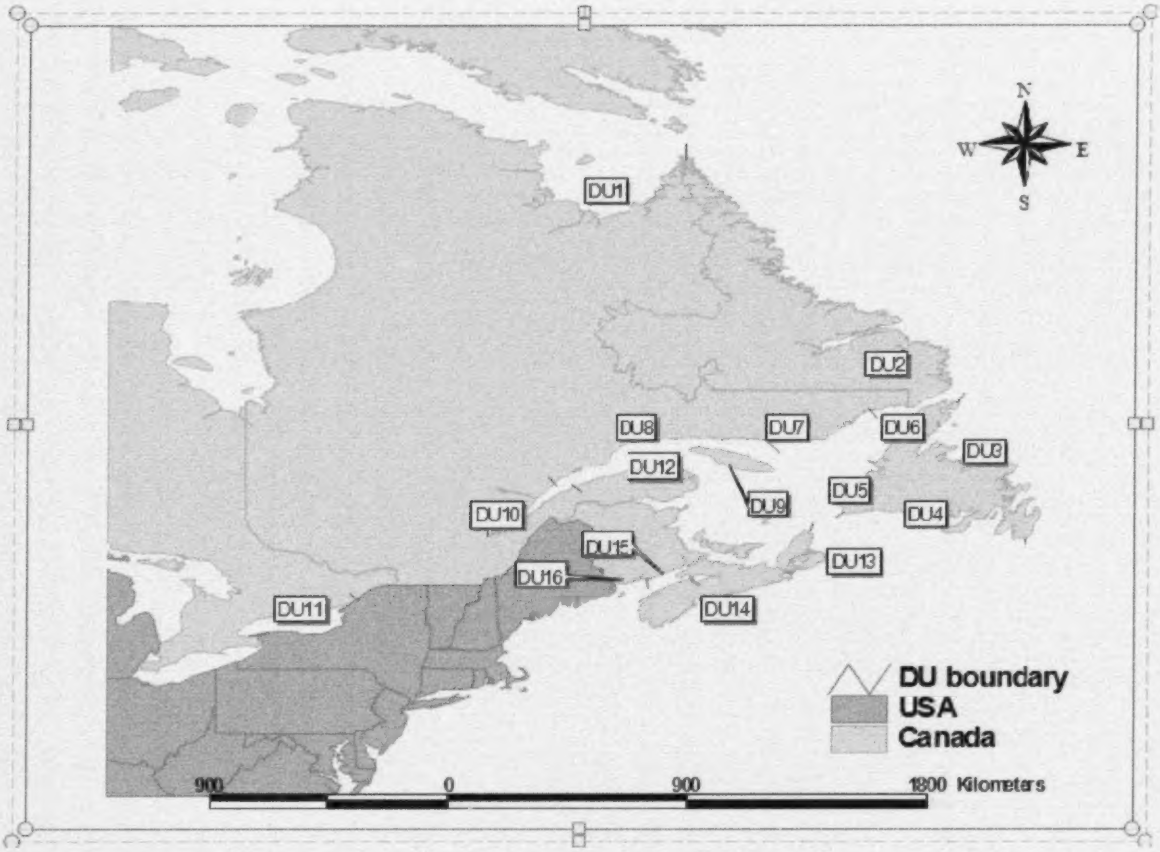

DU1
N
W
E
S
DU2
DU8
DU7
DU6
DU3
DU12
DU5
DU9
DU10
DU4
DU15
DU13
DU16
DU11
DU14
DU boundary
USA
Canada
900
0
900
1800 Kilometers

Figure 9. Proposed designatable units (DU) for Atlantic Salmon in eastern Canada.

Designatable Unit 1 – Nunavik (Quebec fishing area designation - Q11; CU 1)

This DU extends from the tip of Labrador (approximately 60°29' N, 64°40' W) west along Ungava Bay to the western extent of the species' range, and represents the most northerly known populations of Atlantic Salmon in North America. Atlantic Salmon in this unit are geographically disjunct from southern populations with a substantial distance between these populations and those along the Labrador coast (~650 km; limited survey work and Aboriginal traditional knowledge suggest there are no self-sustaining populations between DU 1 and DU 2). Some portions of the Ungava populations also appear to have local migratory patterns (Power 1969, Robitaille *et al.* 1986), while others range broadly (Power *et al.* 1987). Genetic data suggest that these populations are distinct from their nearest neighbours and there is little genetic evidence of straying between Ungava and other regions (Fontaine *et al.* 1997, Dionne *et al.* 2008). There have been no known stocking events in this DU.

Designatable Unit 2 – Labrador (Salmon Fishing Areas – 1, 2, 14a, and 5 rivers of Quebec fishing area – Q9; CUs 2, 3 and part of 26)

This DU extends from the northern tip of Labrador (approximately 60°29' N, 64°40' W) south along the coast of Labrador to the Napitipi River in Quebec. Given the large size of this geographic region there is substantial potential for smaller regional groupings within the DU, particularly in the Lake Melville area. However, the available information only supports a clear separation from other regions at the southern portion of the DU. Within DU 2, genetic data suggest reasonable potential for gene flow and hence re-colonization throughout much of the southern portion of the unit (King *et al.* 2001, Verspoor 2005, Adams 2007 (F_{ST} = 0.017), Dionne *et al.* 2008). There is evidence from tagging studies, however, that salmon from the southern portion of this unit do not migrate north of Lake Melville (Anderson 1985, Reddin and Lear 1990). Within-unit comparisons showed weak differentiation between northern and southern rivers where pair-wise heterogeneity was calculated (King *et al.* 2001). Verspoor (2005) did not detect a pattern of differentiation between northern and southern Labrador samples. However, the only sample from Lake Melville (Cape Caribou) was significantly different from the other Labrador samples and suggests the potential for a separate DU at Lake Melville. Unfortunately the Cape Caribou sample was comprised only of a small sample of parr and thus other supporting information is required to justify the creation of a separate DU for Lake Melville. The DU 2 populations did show significant divergence from other nearby DUs including DU 7 (Eastern North Shore) (Dionne *et al.* 2008) and the insular Newfoundland DUs (F_{ST} = 0.021; Adams 2007).

The salmon in DU 2 also appear to have variable life histories with no clear pattern across the DU (Chaput *et al.* 2006a). They show significant life history divergence from the nearby DUs of insular Newfoundland and the eastern North Shore of Quebec (Chaput *et al.* 2006a) (MSW versus grilse populations). There have been no known stocking events in this DU.

Designatable Unit 3 – Northeast Newfoundland (Salmon Fishing Areas 3-8; CU 4)

This DU extends from the northern tip of Newfoundland (approximately 51°37' N, 55°25' W) south and east along the northeast coast of the Island to the southeast tip of the Avalon Peninsula (approximately 46°38' N, 53°10' W). The salmon of the northeast coast of Newfoundland are unique in North America, in that they appear to have genetic profiles intermediate to European and North American salmon (King *et al.* 2000). Genetic data also suggest that there are distinct differences between salmon populations in DU 3 and salmon populations in both Labrador, and southern and western Newfoundland (Verspoor 2005, Adams 2007, Palstra *et al.* 2007). The salmon in DU 3 also exhibit life history variation distinct from other nearby DUs (Chaput *et al.* 2006). Mean age of smoltification was intermediate between Labrador and the rest of insular Newfoundland (3-5 years versus 5-7 in Labrador and 2-4 in southern Newfoundland DUs), and a high proportion of grilse were relatively small 1SW females. This portion of the Canadian range also has the highest incidence of repeat spawners. Juveniles in this DU make heavy use of lacustrine habitat for rearing (e.g., Hutchings 1986). The Exploits and Terra Nova Rivers were stocked extensively in the 1980s and 90s after new habitat was made accessible with fishways (Mullins *et al.* 2003).

Designatable Unit 4 – South Newfoundland (Salmon Fishing Areas 9-12; CUs 5, 6)

This DU extends from the southeast tip of the Avalon Peninsula, Mistaken Point (approximately 46°38' N, 53°10' W) westward along the south coast of Newfoundland to Cape Ray (approximately 47°37' N, 59°19' W). Unlike DU 3, freshwater habitat in DU 4 tends to have relatively low pH values (5.0-6.0). Genetic data suggest that populations along this coast have reduced gene flow among local rivers and between DU 4 and other regions of the Island (Palstra *et al.* 2007). Adams (2007) also demonstrated significant genetic differences between two rivers from DU 3 and two rivers found on the southern Avalon (southeastern DU 4) using a suite of 10 microsatellite markers. Like Palstra *et al.* (2007), Verspoor (2005) found significant genetic differentiation among south coast rivers, but there did not appear to be a geographic pattern to the divergence. The relatively high levels of population structure in DU 4, as evidenced by the substantially higher interregional F_{ST} values on the south coast of the Island reported by Palstra *et al.* (2007), suggest potential subdivision of this DU in the future.

Salmon in DU 4 also experience substantially different ocean conditions than fish in DUs 2-3, entering an area influenced by the Gulf Stream versus the Labrador Current. Population trends for south coast rivers also appear to be distinct from the other DUs in Newfoundland. Much like the genetic data, the life history data for the south coast are variable and show no clear geographic pattern (Chaput *et al.* 2006a). There is a mix of early and late runs, smolt age is variable and both the proportion of female grilse and migratory routes appear to vary along the coast. Rocky River was stocked after the construction of a fishway at the river mouth. Anadromous salmon were absent prior to the fishway construction.

Designatable Unit 5 – Southwest Newfoundland (Bay St. George region) (Salmon Fishing Area 13; CU 7)

This DU extends from Cape Ray (approximately 47°37' N, 59°19' W) northwards along the west coast of Newfoundland to approximately 49□24' N, 58□15' W. This particular DU is the only region of insular Newfoundland with significant numbers of MSW salmon (Dempson and Clarke 2001) and minimal lacustrine habitat. Genetic comparisons of populations in this region with those in the rest of the Island suggest the populations here represent a distinct group, but that within the region gene flow appears to be higher than in DUs 3 and 4 (lowest F_{ST} values reported by Palstra *et al.* (2007) and Verspoor (2005)). DU 5 also has the youngest mean smolt ages (3 years) on insular Newfoundland and the lowest proportion of female grilse. DU 5 is separated from mainland DUs by the Gulf of St. Lawrence, and genetic data suggest low levels of gene flow between insular populations and the mainland (Verspoor 2005). Hughes Brook and Corner Brook stream have both been stocked in this DU.

Designatable Unit 6 – Northwest Newfoundland (Salmon Fishing Area 14a; CU 8)

This DU extends northward along the west coast of Newfoundland, from approximately 49□24' N, 58□15' W to the tip of the Great Northern Peninsula (approximately 51°37' N, 55°25' W). Smolts from populations of DU 6 most likely migrate northward through the Strait of Belle Isle (B. Dempson, Dept. of Fisheries and Oceans, Pers. Comm.) and they have life histories that are mixed and intermediate between DU 2 and DU 5 (Chaput *et al.* 2006a). Freshwater habitat in DU 6 is significantly more alkaline than the rest of insular Newfoundland, due to a large amount of limestone in the region's geology. Unfortunately, genetic data for this DU are sparse. Several rivers in this DU such as the Big East, St. Genevieve and River of Ponds have a MSW component. From 1972-1976, DFO annually transferred 50-300 adult salmon from Western Arm Brook into a good spawning habitat upstream from the fishway in the Torrent River.

Designatable Unit 7 – Quebec Eastern North Shore, (Quebec Fishing Area – 9, western portion; most of CU 26)

This DU extends from the Napitipi River (not inclusive) westward along the north shore of the St. Lawrence to the Kegaska River (inclusive) in the west. Dionne *et al.* (2008) used microsatellite markers, temperature, difficulty of river ascension, and 1SW percentage to differentiate among regions of the North Shore. DU 7 is characterized by populations with high proportions of 1SW salmon and rivers with lower temperature regimes than DU 8. The genetic data also suggest these populations have lower levels of gene flow within the DU than within other areas of the North Shore (Dionne *et al.* 2008) (mean $F_{ST} = 0.037$ versus 0.027 in DU 8). There are no known stocking events in this DU.

Designatable Unit 8 – Quebec Western North Shore (Quebec Fishing Areas – 7 and 8; CUs 24, 25)

This DU extends eastward from the Natashquan River (inclusive) along the Quebec North Shore to the Escoumins River in the west (inclusive). Dionne *et al.* (2008) provided microsatellite, habitat and life history data that segregate this region of the North Shore from DUs 7 and 10. The eastern edge of the DU appears to be a transitional area to DU 7 (Dionne *et al.* 2008) and does not have a clear geographic feature as a boundary. The western edge of the DU transitions into DU 10 in a similar fashion. The salmon of DU 8 have the highest proportion of MSW salmon by a significant margin relative to the other populations in the North Shore DUs. Stocking in this DU was substantial and has occurred in multiple rivers (Fontaine *et al.* 1997; Dionne *et al.* 2008).

Designatable Unit 9 – Anticosti Island (Quebec Fishing Area 10; CU 27)

This DU encompasses Anticosti Island. DU 9's freshwater habitat is lower gradient than DU 7's. However, in terms of temperature, DU 9's freshwater habitat is similar to DU 7's (based on degree days: 945 versus 938) but is cooler than DU 8, 10, 11 or 12. Genetic data from Dionne *et al.* (2008) show divergence of DU 9 with neighbouring DUs. These data also suggest that gene flow within DU 9 is high with no significant differences among several rivers ($F_{ST} = 0.002$). Some stocking has occurred in this DU in the past, mainly in the Jupiter River. For example, one-year and two-year-old smolts, as well as fall fingerlings, were stocked in this river during 1993 to 1995 (Caron *et al.* 1996).

Designatable Unit 10 – Inner St. Lawrence (Quebec Fishing Area 4, 5 and 6; CUs 21, 22, 23, part of 20)

This DU extends west along the northern shore of the St. Lawrence from the Escoumins River (not included) into the lower St. Lawrence River and returns eastward along the southern shore of the St. Lawrence to the Ouelle River (included). DU 10 is characterized by a higher proportion of 1SW salmon than DU 8 and a lower mean age at smoltification. Freshwater habitat is also the warmest along the Quebec North Shore. The genetic data from Dionne *et al.* (2008) suggests limited gene flow between this DU and DUs 8 and 12. Stocking in this DU was substantial and has occurred in multiple rivers (Fontaine *et al.* 1997, Dionne *et al.* 2008).

Designatable Unit 11 – Lake Ontario[iii]

Approximately 67 tributaries of Lake Ontario were known to support runs of Atlantic Salmon. Scales obtained from two adult museum specimens indicate an exclusively freshwater growth history, suggesting that at least some salmon populations that originally inhabited Lake Ontario were potamodromous (freshwater resident) (Blair 1938).

Some authors have suggested that prior to the construction of the R.H. Saunders Dam in 1958 in the St. Lawrence River, some Atlantic Salmon would have migrated a distance of 2,400 km to the Atlantic Ocean (summarized in Parsons 1973). However, since potamodromous individuals in Lake Ontario experienced improved growth in Lake Ontario, similar to that acquired in the marine environment for anadromous populations, it seems there would have been few ecological benefits for Lake Ontario salmon to undertake an extensive marine migration. Unfortunately, there are few data to support or oppose the existence of anadromy in at least some Lake Ontario populations. Nonetheless, Lake Ontario Atlantic Salmon differed notably from other DUs in Canada in that age of smoltification was the lowest in the Canadian range, there were spring and fall spawning runs, and if anadromy did occur, it would likely have required prolonged staging in freshwater. These facts, along with the general concurrence of biologists that at least many populations were potamodromous, suggest that Lake Ontario Atlantic Salmon population were likely reproductively isolated from other Atlantic Salmon populations in North America.

Designatable Unit 12 – Gaspé-Southern Gulf of St. Lawrence (Quebec Fishing Area 1, 2 and 3; Salmon Fishing Areas 15, 16, 17 and 18; CUs 9, 10, 11, 12, 18, 19, part of 20)

This DU extends from the Ouelle River (excluded) in the western Gaspé to the northern tip of Cape Breton (approximately 47°02' N, 60°35' W). Data from Dionne *et al.* (2008) suggest that the Gaspé and northeastern New Brunswick represent a regional grouping. The mean F_{ST} (0.011) between rivers was the second lowest among the seven regions identified, after DU 9. Dionne *et al.* (2008) did not include the southeastern Gulf of St. Lawrence in their analysis, but the authors of this report could find no evidence that the southeastern Gulf exhibited genetic or life history divergence from the western Gulf of St. Lawrence. There is some evidence from neutral genetic markers that rivers of western Cape Breton may be divergent from the western Gulf (P. O'Reilly, Dept. of Fisheries and Oceans, Pers. Comm.), but more data are needed. Verspoor (2005) also found relatively little evidence of divergence within this region. Thus, the southeastern Gulf rivers were included in the unit. Genetic data are not available for Atlantic salmon on Prince Edward Island. While salmon populations in small streams probably reflect the province's original populations, those in larger PEI streams are heavily influenced by stocking from eastern New Brunswick. Size distributions and run-timing of adults returning to these streams are also broadly similar to those found elsewhere in the southeastern Gulf (Cairns *et al.* 2009). For these reasons, PEI salmon populations are placed within DU 12. As stated above, this region has an extensive history of stocking (Fontaine *et al.* 1997 Breau *et al.* 2009, Cairns *et al.* 2009, Cameron *et al.* 2009, Chaput *et al.* 2010). PEI both provided salmon eggs for other rivers in the Maritimes and received substantial numbers of eggs and juveniles from mainland rivers. For most of this DU, stocking events have been common for at least the past 100 years.

Designatable Unit 13 – Eastern Cape Breton (Salmon Fishing Area 19; CUs 13, 14)

This DU extends from the northern tip of Cape Breton Island (approximately 47°02' N, 60°35' W) to northeastern Nova Scotia (approximately 45°39'N, 61°25' W). The populations in this DU appear to be genetically distinct from its southern neighbour, DU 14 (Nova Scotia Southern Upland) (Verspoor 2005). Within this DU there is substantial life history variation between Atlantic coast rivers and the Bras d'Or Lakes rivers. The Atlantic rivers, for example have higher proportions of 1SW fish. Substantial differences in freshwater habitat (e.g., stream gradient) and divergent demographic trends suggest that there is some structuring within the DU. However, sparse genetic data do not appear to support any clear geographic pattern (P. O'Reilly, Dept. of Fisheries and Oceans, Pers. Comm.). Stocking in this DU has occurred in some rivers since at least 1902 when the federal government opened the Margaree hatchery (DFO 1997), but for the most part has been discontinued for over a decade.

Designatable Unit 14 – Nova Scotia Southern Upland (Salmon Fishing Area 20-21; CU 15)

This DU extends from northeastern mainland Nova Scotia (approximately 45°39'N, 61°25' W) southward and into the Bay of Fundy to Cape Split (approximately 45°20' N, 64°30' W). Both mtDNA and microsatellite data suggest that gene flow between DU 14 and the neighbouring DUs (13 and 15) is minimal (DFO and MRNF 2008). Many rivers in DU 14 have freshwater habitat with relatively low pH. They also have lower proportions of MSW fish than their northern neighbours. Southerly populations in DU 14 also have some of the youngest smolt ages reported in Canada (Chaput *et al*. 2006a). This DU also has an extensive history of stocking, including recent efforts to slow the decline of a few of the severely depressed populations in the DU (J. Gibson Pers. Comm.).

Designatable Unit 15 – Inner Bay of Fundy (portions of Salmon Fishing Areas 22 and 23; CU 16)

This DU extends from Cape Split (approximately 45°20' N, 64°30' W) around the Inner Bay of Fundy to a point just east of the Saint John River estuary (approximately 45°12' N, 65°57'). This DU has strong genetic differentiation from nearby DUs and appears to exhibit unique migratory behaviour (within the Bay of Fundy/Gulf of Maine) (COSEWIC 2006b). Over 40 million salmon of differing ages have been stocked into rivers of this region since the turn of the 20th century. Early sources are unclear, but recent stocking has been done with inner Bay of Fundy progeny (Gibson *et al*. 2003). These recent stocking events, intended to maximize exposure of salmon to wild environments, are a part of a captive-rearing program thought to have prevented, at least temporarily, the extinction of salmon in this DU (Gibson *et al*. 2008).

Designatable Unit 16 – Outer Bay of Fundy (Portion of Salmon Fishing Area 23; CU 17)

This DU extends westwards from just east of the Saint John River estuary (approximately 45°12′ N, 65°57′) to the border with the United States of America. Genetic data suggest minimal gene flow between this DU and nearby DUs 14 and 15 (King *et al.* 2000, Verspoor *et al.* 2002 and Verspoor 2005). Within this DU the Serpentine River has a unique run of salmon that return late in the fall and spawn the following year (Saunders 1981). DU 16 also has a higher proportion of MSW salmon migrating to the North Atlantic than DU 15 (Amiro 2003). Termination of this DU at the border with the United States reflects the scope of this report. From a biological perspective, the U.S. populations may be included in the DU (relationship not examined in this case).

Table 1. Summary of DU characteristics.

DU	Adjacent DUs	Salmon/Quebec Fishing Areas	Genetic Variation	Phenotypic Variation	Geographic	Ecological/Habitat
1 - Nunavik	2	Q11	Limited gene flow with other DUs based on neutral markers Verspoor (2005), Dionne *et al.* (2008), Fontaine *et al.* (1997).	Evidence of local migratory routes.	Disjunct from the rest of the species distribution (~650 km of coastline).	At the northern extreme of the species' range in Canada, Arctic-like conditions.
2 - Labrador	1,3,6,7	SFA 1,2, 14b and 6 rivers from Q9	Minimal evidence of sub-structuring in southern portion of DU, data deficient in northern portion. Some evidence Lake Melville may be distinct King *et al.* (2001), Adams (2007), Dionne *et al.* (2008).	Higher incidence of MSW fish. Smolt primarily age 4+ (Chaput *et al.* 2006a).	Separated from insular Newfoundland by the Strait of Belle Isle.	Arctic and subarctic conditions in much of the DU. Anadromous Arctic char and brook trout abundant in many watersheds.
3 - Northeast Newfoundland	2,4,6	SFA 3-8	'European-type' mtDNA genotypes present in this area, Low levels of gene flow with other DUs based on neutral genetic markers. Some evidence of within-DU sub-structure King *et al.* 2000, Verspoor (2005), Adams (2007), Palstra *et al.* (2007).	Primarily grilse populations. Smolt predominantly age 4 (Chaput *et al.* 2006a). Highest incidence of repeat spawners in Canadian range. Substantial non-anadromous population components.	All rivers flow directly into open Northeast Atlantic and the Grand Banks.	Relatively low natural pH 6.1-6.5. Low gradient rivers.
4 - South Newfoundland	3,5	SFA 9-12	Evidence of within-DU sub-structuring, but no geographic pattern. Low levels of gene flow with other DUs based on neutral markers Verspoor (2005), Adams (2007), Palstra *et al.* (2007).	Some rivers have early run timing, and median smolt age of 3 years (Chaput *et al.* 2006a). Substantial non-anadromous population components.	Rivers empty into a region influenced by the Gulf Stream versus the Labrador Current.	Relatively low pH water usually < 5.5. Some areas are high gradient systems. Milder climate relative to northern portions of insular Newfoundland.

DU	Adjacent DUs	Salmon/Quebec Fishing Areas	Genetic Variation	Phenotypic Variation	Geographic	Ecological/Habitat
5 - Southwest Newfoundland	4,6	SFA 13	Evidence of higher rates of gene flow within this DU than among adjacent DUs and within other DUs Verspoor (2005), Palstra *et al.* (2007).	Earliest ages of smoltification on the Island. Only DU on insular Newfoundland with a substantial MSW component (Chaput *et al.* 2006a).	Rivers empty in the Cabot Strait and Gulf of St. Lawrence. Close proximity to southern DUs (e.g., DU 13).	Many low gradient streams, limited lacustrine habitat.
6 - Northwest Newfoundland	2,5,7	SFA 14a	Data deficient.	Small MSW component (Chaput *et al.* 2006a).	Rivers flow into the Strait of Belle Isle.	Lacustrine habitat abundant.
7 - Quebec Eastern North Shore	2,6,8,9	Part of Q8 and Q9	Neutral markers suggest higher gene flow within this region than among adjacent DUs. Data suggest western border with DU 8 may be ambiguous. Dionne *et al.* (2008).	Characterized by populations with high proportions of 1SW salmon (Chaput *et al.* 2006a).	No clear geographic boundary with DU 8 or DU 2, but separated from other DUs by Gulf of St. Lawrence	Rivers with lower temperature regimes than DU 8
8 - Quebec Western North Shore	7,9,10	Part of Q7 and Q8	Neutral markers suggest within DU gene flow is higher than among adjacent DUs. Some evidence of transitional areas on borders. Dionne *et al.* (2008)	Highest proportion of MSW salmon by a significant margin relative to the other DUs of the North Shore (Chaput *et al.* 2006a).	No clear geographic boundary with DU 7 or DU 10, but separated from other DUs by Gulf of St. Lawrence.	Higher gradient rivers than nearby DUs (Dionne *et al.* 2008).
9 - Anticosti Island	7,8,10,12, 13	Q10	Neutral markers suggest gene flow within this DU may be variable. Low levels of distinction among some rivers, but clearly divergent from mainland Dionne *et al.* (2008).	Higher proportion of 1SW salmon than many nearby DUs (Chaput *et al.* 2006a).	Distinct island system in the Gulf of St. Lawrence.	Lower gradient rivers (Dionne *et al.* 2008).
10 - Inner St. Lawrence	8,11,12	Q4,5,6	Neutral markers suggest divergence from adjacent DUs Dionne *et al.* (2008).	Lower mean age at smoltification than nearby DUs (Chaput *et al.* 2006a).	NA	Freshwater habitat is also the warmest along the Quebec North Shore.
11- Lake Ontario	10	FMZ 20	Data deficient	Likely potamodromous with the possibility of some anadromous populations. Had the youngest smolt ages in Canadian range.	Inland lake system	Unknown
12 - Gaspé-Southern Gulf of St. Lawrence	9,10,13	Q1,2,3 and SFA 15,16,17,18	Data deficient, but some evidence of divergence at eastern (Dionne *et al.* 2008) and western edges (P. O'Reilly pers. comm.)	Variable life histories across the DU, but no clear geographic pattern (Chaput *et al.* 2006a).	Encompasses entire southern Gulf of St. Lawrence and PEI.	Variable across the DU. PEI is a distinct island system. Miramichi River is the dominant system.

DU	Adjacent DUs	Salmon/Quebec Fishing Areas	Genetic Variation	Phenotypic Variation	Geographic	Ecological/Habitat
13 - Eastern Cape Breton	12,14	SFA 19	Absence of mitochondrial haplotype observed in DU 14 Verspoor *et al.* (2005).	Variable life histories across the DU. Some evidence of western and eastern geographic pattern (Chaput *et al.* 2006a).	Island system. Many of the DU rivers flow into the open Atlantic Ocean. Large inland lake system.	Higher gradient rivers than nearby DUs.
14 - Nova Scotia Southern Upland	13,15	SFA 20, 21	Allozyme, mitochondrial, and microsatellite data suggest divergence among DUs 14,15,16. Verspoor (2005), Verspoor *et al.* (2005). O'Reilly, pers. com.	Lower proportions of MSW fish than their northern neighbours. Southerly populations in DU 14 also have some of the youngest smolt ages reported in Canada (Chaput *et al.* 2006a).	Rivers flow into Western North Atlantic Ocean	Many rivers in DU 14 have freshwater habitat with relatively low pH.
15 - Inner Bay of Fundy	14,16	Portions of SFA 22 and 23	Allozyme, mitochondrial, and microsatellite data suggest divergence among DUs 14,15,16. Verspoor (2005), Verspoor *et al.* (2005). O'Reilly, pers. com.	Unique migratory behaviour.	Confined to the inner Bay of Fundy.	Unique Bay of Fundy tidal system.
16 - Outer Bay of Fundy	15	Portion of SFA 23	Allozyme, mitochondrial, and microsatellite data suggest divergence among DUs 14,15,16 Verspoor (2005), Verspoor *et al.* (2005). O'Reilly, pers. com.	DU 16 has a higher proportion of MSW salmon migrating to the North Atlantic than DU 15 (Chaput *et al.* 2006a). Several systems with unusual run timing.		

DISTRIBUTION

Global range[iv]

Atlantic Salmon originally occurred in every country whose rivers flow into the North Atlantic Ocean and Baltic Sea (Mills 1989) (Figure 10). The range of Atlantic Salmon extended southward from northern Norway and Russia along the Atlantic coastal drainage to Northern Portugal including rivers in both France and Spain (MacCrimmon and Gots 1979). In North America, the range of the anadromous Atlantic Salmon was northward from the Hudson River drainage in New York State, to outer Ungava Bay in Quebec (MacCrimmon and Gots 1979). Non-migratory or non-anadromous forms of Atlantic Salmon occur in areas of Europe, and North America.

The current distribution is reduced compared to the historical range and the number of rivers supporting spawning runs in each country, as well as the estimated population sizes, are much lower than those recorded historically.

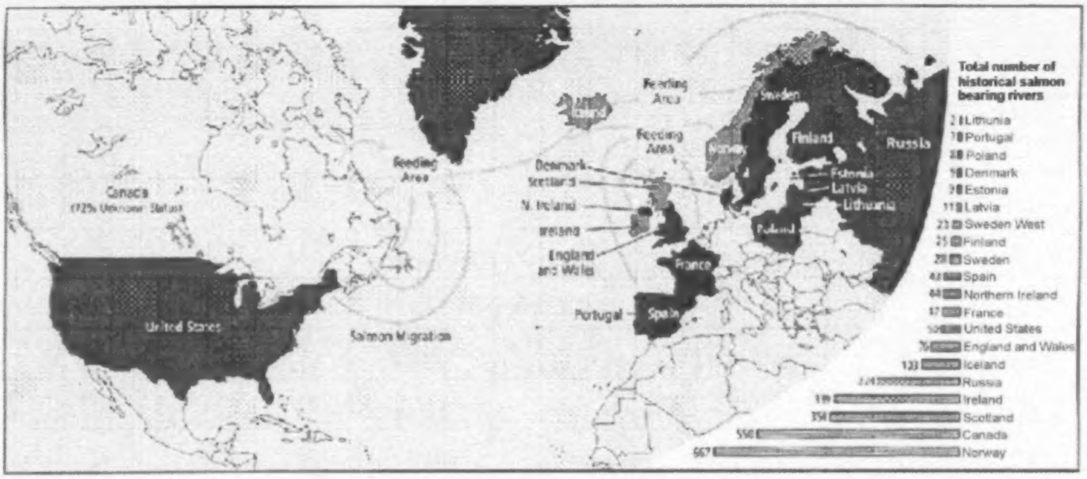

Feeding Area
Feeding Area
Feeding Area
Canada
(72% Unknown Status)
United States
Salmon Migration
Denmark
Scotland
N. Ireland
Ireland
England and Wales
Portugal
Spain
France
Sweden
Norway
Finland
Russia
Estonia
Latvia
Lithuania
Poland
Total number of historical salmon bearing rivers
Lithuania
Portugal
Poland
Denmark
Estonia
11 Latvia
23 Sweden West
25 Finland
28 Sweden
Spain
44 Northern Ireland
57 France
United States
England and Wales
133 Iceland
Russia
Ireland
354 Scotland
550 Canada
667 Norway

Figure 10. Current global distribution of Atlantic Salmon (*Salmo salar*), excluding Canada. Arrows indicate migration patterns of wild salmon. The total number of historical salmon-bearing rivers worldwide is indicated at the right of map. COSEWIC (2006).

Canadian range[v]

The Canadian range is roughly one-third the area of the total global range, and extends northward from the St. Croix River (at the border with Maine, U.S.A.) to outer Ungava Bay of Quebec, plus one population in Eastern Hudson Bay (MacCrimmon and Gots 1979, Scott and Crossman 1973). Salmon occupy or have occupied at least 700 rivers in the Canadian range[vi], not including many smaller rivers that have been occupied intermittently.

Extent of occurrence and area of occupancy

With the exception of the extinct Lake Ontario population (DU 11) the extent of occurrence of each of the Atlantic Salmon DUs includes a large portion of the North Atlantic Ocean, substantially greater than 20,000 km^2. Accurate estimates of area of occupancy during the most spatially confined life history stages, spawning and early rearing of juveniles, are not possible for the great majority of rivers occupied by salmon, based on current knowledge. To determine whether index of area of occupancy (IAO) might fall below important thresholds (2,000 km^2 or 500 km^2) for status assessments of individual DUs, estimates of IAO were made for eight DUs with small numbers of rivers. DU 15 (Inner Bay of Fundy), for which area of occupancy was previously estimated to be 9 km^2 (COSEWIC 2006b) was not included in this analysis. IAO was estimated using

2 x 2 km grids overlaying potential river habitat, beginning with main stems of known spawning rivers. If these summed to less than 2,000 km^2 for any DU, tributaries were also included in the analysis. Where available, information about barriers limiting access of migratory salmon was taken into account.

Using this approach, estimated IAO exceeded the 2,000 km^2 threshold for each of the following six DUs (see Technical Summaries for exact values of estimates): DU 1, 7, 8, 9, 14, 16. Two DUs 10 (Inner St. Lawrence) and13 (Eastern Cape Breton), had estimated IAOs below 2,000 km^2, 1552 and 1684 km^2, respectively.

HABITAT

Atlantic Salmon have complex and plastic life histories that begin in freshwater and may involve extensive migrations through freshwater and marine environments before returning to fresh water to spawn.

Freshwater habitat requirements[vii]

Atlantic Salmon rivers are generally clear, cool and well oxygenated, with low to moderate gradient, and possessing bottom substrates of gravel, cobble and boulder (COSEWIC 2006b).

Habitat is considered a limiting resource to freshwater production and is used to set conservation requirements for Canadian rivers (O'Connell *et al.* 1997a). Loss of freshwater habitat since European colonization has resulted in dramatic declines in the range and abundance of Atlantic Salmon (Leggett 1975). A relatively small but locally significant amount of habitat has been created by enhancing passage through the removal of natural barriers. This has increased salmon population size in several rivers (e.g. Mullins *et al.* 2003).

Freshwater habitat use by Atlantic Salmon is diverse, widely documented and the subject of substantial reviews (Bjornn and Reiser 1991, Gibson 1993, Bardonnet and Bagliniere 2000, Armstrong *et al.* 2003a, Rosenfeld 2003, Amiro 2006). Spawning beds are often gravel areas with moderate current and depth (Fleming 1996), but habitats used by juvenile and adult salmon range across freshwater fluvial, lacustrine and estuarine environments. Individual fish may often use several habitat types during their freshwater residency (Erkinaro and Gibson 1997, Bremset 2000) for demographic (Saunders and Gee 1964), and ecological reasons (Morantz *et al.* 1987, Bult *et al.* 1999).

Juvenile salmon typically maintain relatively small feeding territories in streams, which can be relocated when individuals undergo larger-scale movements to seek improved foraging conditions, refuge (thermal or seasonal) and/or precocious spawning (McCormick *et al.* 1998). In some areas (e.g. Newfoundland), juveniles also occupy lacustrine habitats where growth benefits are accrued (Hutchings 1986). In winter, parr may occupy interstitial spaces in the substrate (Cunjak 1988) and/or move to lacustrine habitats (Robertson *et al.* 2003). Ultimately, home ranges in freshwater are abandoned when smolt begin to migrate to the marine environment (the Lake Ontario populations, which likely migrated to lake environments, were an exception to this generalization). The propensity for migration underscores the importance of habitat connectivity, not only to allow adults to reach spawning grounds, but also for seasonal movements of juveniles and ontogenetic shifts in habitat.

In Lake Ontario, adult 'Lake' salmon typically remained in the lake until immediately prior to spawning, at which time they ascended their natal streams and established spawning sites. The small size of most tributaries of Lake Ontario and their low flow and volume were, in most cases, unfavourable for the extended residency of large salmon (Parsons 1973). Adults rarely remained in the streams longer than one week after spawning (Parsons 1973). Little is known about the preferred lacustrine habitat of Atlantic Salmon except that lakes with deep, cool, oligotrophic conditions, a forage base that includes rainbow smelt (*Osmerus mordax*), and the presence of feeder streams providing suitable spawning and nursery habitat, appear to be the most ecologically suitable (MacCrimmon *and* Gots 1979, Cuerrier 1983). Historically, Lake Ontario salmon may have depended on cisco and later alewife before smelt entered the lake in the 1930s. Lake Ontario most likely served the same function for adult and juvenile lake salmon as the ocean did for anadromous populations.

Chemical conditions also play a role in defining salmon habitat. Atlantic Salmon populations can experience reduced production or even extirpation in conditions of low pH (DFO 2000). Tolerance is life-stage dependent with fry and smolt being the most sensitive. Generally rivers that have pH's between 4.7 and 5.0 are considered moderately impacted and those below 4.7 are considered acidified (DFO 2000), and are unlikey to be able to support salmon populations.

Temperature has been described as the most pervasive abiotic attribute controlling the production of teleost fishes in streams (Heggenes *et al.* 1993). Relative to other salmonids, Atlantic Salmon parr are relatively tolerant of high water temperatures (Elliot 1991). Temperatures above 22°C are unsuitable for feeding (Elliot 1991) and the maximum incipient lethal temperature (the temperature at which all salmon would exit a habitat if the opportunity were available) was estimated to be 27.8°C (Garside 1973). There is a gradual increase in smolt age associated with increasing latitude which is considered to depend upon growth opportunities in spring and summer (Metcalfe and Thorpe 1990). Therefore, it is entirely possible that an optimum temperature regime exists, affecting Atlantic Salmon abundance via smolt productivity.

Available habitat is a direct function of discharge (Bovee 1978) and exposure of juvenile populations to extended low flow periods may limit production in streams. Low flows have also been widely observed to delay entry of returning spawners to freshwater environments (Stasko 1975, Brawn 1982). Variation in flow, however, is normal in the temperate streams that salmonids occupy. Atlantic Salmon have been noted for their capacity to cope with this variation in flow and associated physical constraints relative to other sympatric salmonids. Juvenile salmon were noted to move from pool to riffle habitats at higher discharges (Bult *et al.* 1999), which is complementary to the noted preference of pools at low discharge (Morantz *et al.* 1987). This adaptability enables juvenile salmon to occupy extensive sections of streams that experience flow and temperature variation.

The migratory behaviour exhibited by Atlantic Salmon makes them particularly vulnerable to the negative effects of obstructions. Both natural and man-made barriers to fish passage severely reduce the production of salmon by restricting mature salmon from reaching spawning habitat and preventing juveniles from reaching feeding and refuge habitats. In general, most obstructions in excess of 3.4 m in height will block the upstream passage of adult salmon (Powers and Orsborn 1985). Ideally, a passable falls will have a vertical drop into a plunge pool with a depth 1.25 times the height. Depending on the shape of the falls and plunge pool, the maximum height can be considerably less. Furthermore, since jumping and swimming capacity is a function of body length (Reiser and Peacock 1985), the ability of juveniles to surmount barriers is greatly reduced relative to adults.

Marine habitat requirements[viii]

Salmon move, as juvenile smolts or post-spawning 'kelts', from fresh water to brackish estuaries and then to the open ocean (Figure 11). O'Connell *et al.* (2006) report that it is in the ocean where "growth... is rapid relative to that in fresh water... mass increases about 75-fold between the smolt stage and 1SW salmon stage, and over 200-fold from smolts to 2SW salmon". Overall natural mortality in the sea is high and variable and there are many factors that can affect the survival of Atlantic Salmon, some habitat-related (Reddin 2006). However, Reddin (2006) also reports "population-specific information is lacking concerning the cause of these mortalities and this is partly because detailed information on migration routes and distribution is generally unavailable for specific populations, although it is thought that their distributions generally overlap in the North Atlantic."

Survival rates associated with the transition from fresh water to ocean life for Atlantic Salmon, whether for smolts or kelts, have an important influence on year-class strength (Reddin 2006). It is generally thought that water temperature is the main controlling environmental variable for smoltification (although photoperiod is also important). The smolt transformation process is accompanied by changes in metabolic rate, with increases in energy demands underpinning the need for the fish to immediately begin feeding. Of all the variables influencing survival of 'postsmolt' (individuals experiencing their first several months at sea) salmon, temperature is particularly important because temperature regulates metabolic rate. If postsmolts are to survive, individuals must quickly adapt to their new physical environment and be able to escape predators and capture prey. Temperatures occupied by salmon range from below 0 to nearly 20°C, although most were 8-15°C (Reddin 2006). The length of time spent in or near the home estuary is thought to be as brief as 1-2 tidal cycles and may limit opportunities for predation. In general, postsmolt movement to oceanic areas is rapid. Tracking studies confirmed this rapid movement away from estuaries towards the open sea and showed that migration was influenced by tidal currents and wind (Hedger *et al.* 2008; Martin *et al.* 2009). One exception was in the Gulf of St. Lawrence where salmon postsmolts were caught in a nearshore zone late in the summer; presumably long after they had left their home river and estuary (Dutil and Coutu 1988). In North America, movement of postsmolts, once in the open sea, is generally northwards.

Research surveys for postsmolts in the Northwest Atlantic have yielded highest catches and catch rates between 56° and 58° N in the Labrador Sea; capture dates and behaviour suggest that some postsmolts probably overwinter there as well (Reddin 2006). Postsmolts in the Labrador Sea originate from rivers over much of the geographical range of salmon in North America, but the degree of their migration to the Labrador Sea varies by population. Postsmolts have also been caught as bycatch in herring gear in the northern Gulf of St. Lawrence in late summer. The winter destination of these salmon remains unknown. Postsmolts from rivers in the inner Bay of Fundy have been observed to remain in the Bay of Fundy until late summer. Although the overwinter location of iBoF salmon is unknown, the lack of tag recoveries from distant intercept fisheries indicates that iBoF salmon do not go as far north as other salmon stocks.

In spring, adult salmon are generally concentrated in abundance off the eastern slope of the Grand Bank and less abundantly in the southern Labrador Sea and over the Grand Bank. During summer to early fall, adult, non-maturing salmon are concentrated in the West Greenland area and less abundantly in the northern Labrador Sea and Irminger Sea. There are notable exceptions to these tendencies. As for postsmolts from the same area, few adult salmon from the iBoF are caught outside the Bay itself. Another exception is Ungava Bay, where salmon from local rivers are known to overwinter. In some cases adults from 'spring run' populations may be migrating up-river while other conspecifics from nearby populations are well out to sea.

Sea surface temperature (SST) and ice distribution control run timing and distribution in the Northwest Atlantic (Reddin 2006). Salmon are found at sea in water with SSTs of 1-12.5°C, with peak abundance at SSTs of 6-8°C. In the Labrador Sea, 80% of the salmon were found in SSTs between 4-10°C (Reddin 2006). Similarly, tagged Atlantic Salmon kelts were found in temperatures ranging from a low near 0°C to over 25°C, although most of the time kelts stayed in seawater of 5-15°C (Reddin *et al.* 2004). Lethal temperatures for adult salmon occur below 0°C (Fletcher *et al.* 1988). This may explain the tendency of salmon to avoid ice-covered water as reported by May (1973). The significant relationship for SSTs and salmon catch rates suggests that salmon may modify their movements at sea depending on SST.

Lethal seawater temperatures for both wild and farmed salmon smolts adapting to seawater occurred at both low and high temperatures (Sigholt and Finstad 1990, Handeland *et al.* 2003). At the lower end of the temperature range, mortalities of postsmolts occurred at sea temperatures of 6-7°C while at the higher end, mortalities occurred at temperatures over 14°C. This suggests that there may also be environmental windows for successful smolt transition into the sea.

Friedland (1998) reviewed ocean climate influences on salmon life history events including those related to age at maturity, survival, growth and production of salmon at sea. He concluded that ocean climate and ocean-linked terrestrial climate events affect nearly all aspects of salmon life history. For example, higher sea surface temperature has been implicated in increasing the ratio of grilse to MSW salmon (Saunders *et al.* 1983, Jonsson and Jonsson 2004), perhaps through growth rates (Scarnecchia 1983). Also, Scarnecchia (1984), Reddin (1987), Ritter (1989), Reddin and Friedland (1993), Friedland *et al.* (1993), Friedland *et al.* (1998, 2003a, 2003b), and Beaugrand and Reid (2003) showed significant correlations between salmon catches/production and environmental cues, including those related to plankton productivity.

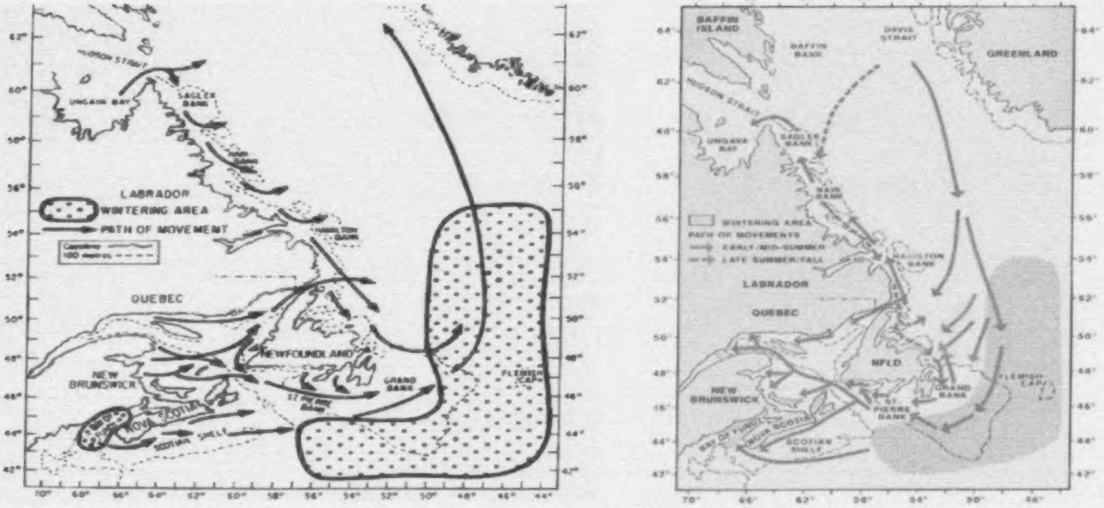

HUDSON STRAIT
UNGAVA BAY
SAGLEK BANK
LABRADOR
WINTERING AREA
PATH OF MOVEMENT
QUEBEC
NEWFOUNDLAND
NEW BRUNSWICK
NOVA SCOTIA
SCOTIAN SHELF
GRAND BANK
FLEMISH CAP
BAFFIN ISLAND
BAFFIN BANK
DAVIS STRAIT
GREENLAND
UNGAVA BAY
NAIN BANK
WINTERING AREA
PATH OF MOVEMENTS
EARLY/MID-SUMMER
LATE SUMMER/FALL
HAMILTON BANK
LABRADOR
QUEBEC
NFLD
NEW BRUNSWICK
BAY OF FUNDY
NOVA SCOTIA
SCOTIAN SHELF
ST PIERRE BANK
GRAND BANK
FLEMISH CAP
70°
66°
62°
58°
54°
50°
46°
64°
62°
60°
58°
56°
54°
52°
50°
48°
46°
44°
42°

Figure 11. Routes of marine migration of postsmolt (left panel) and returning adults (right panel). Figure modified from Reddin (2006).

Freshwater habitat trends[ix]

Dams, with and without fish passages, probably account for the majority of salmon habitat lost in North America. Prior to the development of hydroelectric power there were extensive small mill dams. From 1815 to 1855 more than 30 mills a year were being built in the Atlantic provinces (Dunfield 1985). In Nova Scotia alone, there were a total of 1,798 dams in 1851. In both Nova Scotia and New Brunswick, surveys documented severe habitat loss and destruction caused by dams and mill waste. Estimates made at the time indicated that 70-80% of the habitat for salmon was affected. A similar situation was occurring in 'Upper Canada' at this time and by 1866, salmon in many tributaries of Lake Ontario were severely depleted or extirpated (Dunfield 1985).

With the development of the *Fisheries Act*, shortly after confederation in Canada, some habitat conditions improved. However, a new trend of development began for hydroelectricity in the late 1920s. This technology required the construction of high-head concrete dams that flooded vast areas of rivers. Fish passage structures, when installed, proved to be difficult to operate effectively and in many cases were eventually abandoned due to the lack of fish. Many of the major rivers were developed for hydroelectric power over the next 40 years and more salmon populations were lost. Because hydro developments were often associated with existing falls, not all hydroelectric power developments directly caused the loss of salmon populations. No complete inventory of dams and habitat loss is found in the literature. However, it is notable that five of the largest rivers in Nova Scotia, all of which had salmon prior to European colonization, were subsequently developed for hydropower and no longer have indigenous salmon populations (DFO and MRNF 2008). This observation is clearly not unique to Nova Scotia. Gains in habitat, though modest compared to losses, were achieved by providing passage around natural barriers. For example in Newfoundland, enhancements from the 1940s to the 1990s opened up over 21,600 ha of fluvial habitat to salmon (Mullins *et al.* 2003).

Overall, prior to 1870 as much as 50% of the habitat, or the populations that used those areas, were lost. The majority of these populations and areas were in the Upper St. Lawrence and Lake Ontario (Leggett 1975). The net loss of productive capacity by 1989 was estimated at 16% since 1870, 8% due to loss in productive capacity, 7% due to impoundment, and 3% due to acidification (Watt 1989). During the same period, there was a 2% increase from fish passage development (Watt 1989).

In addition to reductions in habitat availability, freshwater habitat quality has suffered in some areas due to acidification. North American emissions of SO_2 increased during the industrial revolution and peaked in the early 1970s. Approximately 60% of wet sulfate deposition is from human activities in North America. Reductions in emissions have since been achieved and are reflected in both wet sulfate depositions and hydrogen ion concentrations at monitored sites. Anthropogenic sulfate deposition has decreased about one-third since the mid-1980s (DFO 2000). This has caused a large decrease in the deposition of acidifying substances. Unfortunately, the reduction in atmospheric hydrogen (H_+) deposition has not resulted in a substantial decrease in lake acidity at negatively affected sites in Nova Scotia. Furthermore, reduction in acid deposition has not been reflected in the acid neutralization capacity (ANC). As a result, 22% of the 65 salmon rivers on the Southern Upland are 'acidified' and are known to have lost their salmon populations (DFO 2000).

There have been recent efforts to restore habitat in and around traditional salmon spawning streams, particularly in riparian areas, in the Lake Ontario drainage. It is important to note that continued increase in urbanization (and associated increase in impervious cover) of the Greater Toronto Area is likely to have direct and indirect impacts on the chemical and biological characteristics of streams in the region (Stanfield and Kilgour 2006, Stanfield *et al.* 2006). Within the lake itself, there have also been many changes that may negatively affect Atlantic Salmon survival including the introduction of Pacific salmon and other non-native salmonid species (Christie 1973, Scott *et al.* 2003), and the invasion of Lake Ontario by species such as Sea Lamprey (*Petromyzon marinus*) (Christie 1972) and dreissenid mussels.

Quebec and Atlantic populations are also facing varying degrees of changing land-use patterns (e.g. urbanization, forestry, agriculture) and threats from invasive species. These are qualitatively outlined in the Threats and Limiting Factors section.

Marine habitat trends[x]

Climate change is a critical issue for Atlantic Salmon, as it can alter productivity and cause ecological regime shifts (Hare and Francis 1995, Steele 2004, Beamish *et al.* 1997). In the northwest Atlantic, there is evidence that a basin-scale shift (as a consequence of changes in the North Atlantic Oscillation Index) has negatively affected the productivity of Atlantic Salmon (Reddin *et al.* 2000, Chaput *et al.* 2005), and may be linked to downturns in salmon abundance (Dickson and Turrell 2000) and recruitment (Beaugrand and Reid 2003, Jonsson and Jonsson 2004, Chaput *et al.* 2005) in the North Atlantic. Recent research has also suggested that there may be substantial impacts on early growth in the marine environment as a consequence of climate change (Friedland *et al.* 2005, 2006, 2009).

Recent downturns in Atlantic Salmon abundance in the late 1980s and 1990s are unprecedented in magnitude and have drawn attention to the lack of knowledge of salmon ecology during the marine phase (Reddin 2006). Because declines in salmon abundance have been widespread, and because apart from DUs 14-16, there have been few indications of reduced smolt production in fresh water, it has been concluded that the main cause lies within the ocean phase (Reddin and Friedland 1993, Friedland *et al.* 1993). For many rivers where marine survival has been measured, the lowest recorded values have occurred in recent years. These low survivals have coincided with greatly reduced marine exploitation (fishing) achieved through massive reductions in effort or in some cases complete bans (ICES 2005), leaving the conclusion that something other than fishing is the main cause. Beaugrand and Reid (2003) have detected large-scale changes in the biogeography of calanoid copepod crustaceans in the northeast Atlantic in relation to sea surface temperature. It seems that copepod assemblages associated with warm water have shifted about 10° latitude northwards. Declines in a number of biological variables, including salmon abundance, have shown to be correlated with these changes (DFO and MRNF 2008). This regional temperature increase therefore appears to be an important factor driving changes in the dynamics of northeast Atlantic pelagic ecosystems with possible consequences for biogeochemical processes, all fish stocks, and fisheries. Regime shifts associated with climate change are predicted to continue, particularly in the Labrador Sea; now considered to be the "centre of action of climate change in the North Atlantic for the 21st century" (Dickson *et al.* 2007 in Green *et al.* 2008).

Unlike other populations in Canada, inner Bay of Fundy (iBoF) salmon are thought to overwinter in the Bay of Fundy / Gulf of Maine. Nonetheless, poor marine survival remains the primary driver of the collapse of iBoF stocks. Significant declines in marine habitat quality and abundance in this region may be occurring due to at least three mechanisms. First, over 400 tidal barriers have been constructed in the Bay of Fundy, and while their placement predates 1970 (Wells 1999), it is possible that cumulative effects through time have negatively altered the iBoF ecosystem for salmon. Second, a large aquaculture industry has grown in the western Bay of Fundy, northern Gulf of Maine, and southwest region of the Scotian Coast in the past 30 years. Third, primary production is apparently declining in parts of the western North Atlantic (Gregg *et al.*

2003). This decline might cause dramatic changes in energy flow, fish physiological condition and fish community structure, as recently indicated for the eastern Scotian Shelf (Choi *et al.* 2004). Potential causes of the decline in primary production include climate change (Drinkwater *et al.* 2003) and enormous removals of fish biomass by marine fisheries that cannot be matched by net primary production (Choi *et al.* 2004).

Habitat protection/ownership

All or part of 36 salmon rivers occur within the federally protected lands of National Parks (Terra Nova National Park DU 3: 9 rivers; Gros Morne National Park DU 6: 10 rivers; Kouchibouguac National Park DU 12: 4 rivers; Cape Breton National Park DU 13: 11 rivers; Fundy National Park DU 15: 2 rivers; Kejimkujik National Park and Historic Site DU 14: 1 river). Each national park contains only a small proportion of individuals within the corresponding DU and in some cases local populations are extirpated (e.g., Mersey River of Kejimkujik National Park and Historic Site). All remaining rivers flow through lands that are privately or provincially owned.

The federal government's constitutional responsibilities for sea coast and inland fisheries are administered via the *Fisheries Act*. The Act provides Fisheries and Oceans Canada (DFO) with powers, authorities, duties and functions for the conservation and protection of fish and fish habitat (as defined in the *Fisheries Act*) essential to sustaining commercial, recreational and Aboriginal fisheries. The *Fisheries Act* contains provisions that can be applied to regulate flow needs for fish, fish passage, killing of fish by means other than fishing, the pollution of fish-bearing waters, and harm to fish habitat. Environment Canada has been delegated administrative responsibilities for the provisions dealing with regulating the pollution of fish-bearing waters while the other provisions are administered by DFO.

BIOLOGY

The Atlantic Salmon is a member of the family Salmonidae. The fish of this family are fusiform in body shape with a distinguishing characteristic being the presence of an adipose fin between the dorsal and caudal fins that lacks rays. Fish of this family include the salmon, trout, and whitefishes and are commonly sought after by sport fishers in temperate zones. Species of this family generally prefer cool oligotrophic water and frequently exhibit migratory behaviour. Salmonids typically reproduce by digging nests or 'redds' in gravel substrates and depositing fertilized eggs. Atlantic Salmon carry out some of the most extensive migrations in the family, and have one of the widest distributions. It is the adaptation to this ocean-scale migratory behaviour that defines the life history and biology of the species.

Life cycle and reproduction[xi]

Atlantic Salmon display considerable phenotypic plasticity and variability in life history characters (Figure 12). They possess an innate ability to return to their natal rivers to spawn with a high degree of fidelity, despite completing ocean-scale migrations. Spawners returning to rivers are comprised of varying proportions of 'maiden fish' (those spawning for the first time) and 'repeat spawners' (those that have spawned at least once previously). Most maiden salmon consist of smaller fish that return to spawn after one winter at sea and larger fish that return after two or more winters at sea ('2, 3, or 4-sea-winter', also designated as 'multi-sea-winter' [MSW]). There can be significant numbers of consecutive and alternate spawners present in any breeding season. Some rivers also possess a component that returns to spawn after only a few months at sea (0-sea-winter [0SW]). This life history strategy likely does not represent more than a minor component of most populations, with the exception of an unusual population in DU 3 that is entirely 0SW.

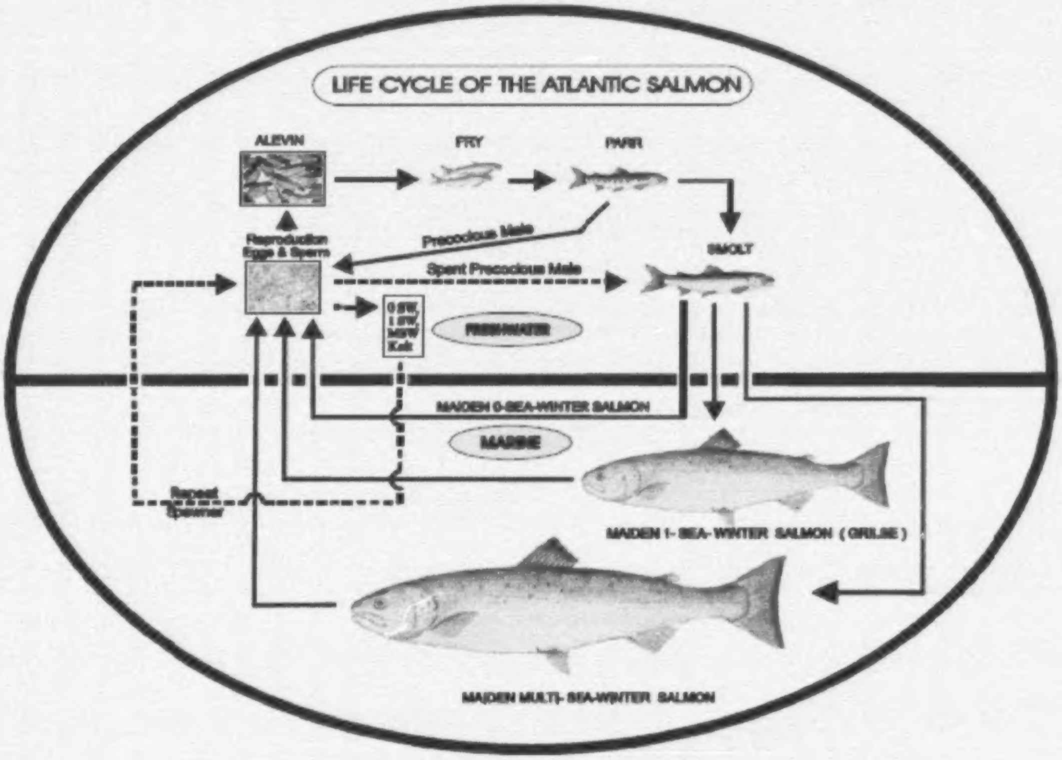

LIFE CYCLE OF THE ATLANTIC SALMON
ALEVIN
FRY
PARR
Reproduction
Eggs & Sperm
Precocious Male
SMOLT
Spent Precocious Male
0 SW
1 SW
MSW
Kelt
FRESHWATER
MAIDEN 0-SEA-WINTER SALMON
MARINE
Repeat
Spawner
MAIDEN 1-SEA-WINTER SALMON (GRILSE)
MAIDEN MULTI-SEA-WINTER SALMON

Figure 12. Generalized life cycle of the Atlantic Salmon (from O'Connell *et al.* 2006).

Collectively over its entire range in North America, adult Atlantic Salmon return to rivers from feeding and staging areas in the sea mainly between May and November, but some runs can begin as early as March and April. In general, run timing varies by river, sea age, year, and hydrological conditions. Deposition of eggs in redds (gravel nests), by oviparous mothers, usually occurs in October and November in gravel-bottomed riffle areas of streams or groundwater gravel shoals in lakes. Fertilization of eggs can involve both adult males and sexually mature precocious males (as young as age 1). Mating behaviour typically entails multiple males of several life history types competing aggressively for access to multiple females. This frequently leads to multiple paternity for a given female's offspring (Jones and Hutchings 2002). Spawned-out or spent adult salmon (kelts) either return to sea immediately after spawning or remain in fresh water until the following spring. Eggs incubate in the spawning nests or redds over the winter months and hatching usually begins in April. The hatchlings or alevins remain in the gravel for several weeks living off large yolk sacs. Upon emergence from the gravel in late May – early June, the yolk sac is absorbed and the free-swimming young fish, now referred to as 'fry' begin active feeding. Parr rear in fluvial and lacustrine habitats for 2-8 years after which time they undergo behavioural and physiological transformations and migrate to sea as smolt.

The substantial variation in freshwater smolt age and sea age at maturity creates substantial variation in age at spawning, ranging from 2-14 years. Typically, salmon smoltify between the ages of 2 to 5 years and return after 1-2 years at sea. A generation time of approximately 5 years is thought an appropriate estimate for much of the species' range in Canada (O'Connell *et al.* 2006). Atlantic Salmon are a relatively short-lived fish species with a maximum age in the 12-14 year range with life spans typically falling in the 4-8 year range (Gibson 1993).

The phenotypic plasticity in life histories found within salmon populations tends to create relatively complex demographic population structures. Not only can the breeding individuals of a population consist of 7-8 cohorts, but sex ratios tend to be highly skewed across the range of age classes. For example, early maturing juveniles are almost exclusively male, while MSW fish are predominantly female in many populations. The exact proportions of mature male parr, grilse, 1, 2, and 3SW fish in a given population is highly variable and the mechanisms driving this differentiation remain unclear.

Fecundity varies considerably both within and among salmon stocks. Egg number and size increase with body size (Thorpe *et al.* 1984, Jonsson *et al.* 1996, O'Connell *et al.* 2008). In a dwarf or stunted freshwater resident population from Newfoundland, mean fecundity was 33.0 eggs (Gibson *et al.* 1996). In contrast, Randall (1989) reported mean fecundities of 12,606 and 16,585 eggs for 3SW and previous spawning salmon in the Restigouche River. Although absolute fecundity varies greatly among individuals, owing to high variability in adult body size, relative fecundity (eggs per kilogram) as a measure of reproductive effort varies much less and is inversely related to fish size. In the Miramichi River, New Brunswick, relative fecundity ranged from 1,331 eggs/kg in previous spawning salmon (mean length 82.1cm) to 2,035 eggs/kg in 1SW fish (Randall

1989). Rouleau and Tremblay (1990) reported values of 1,628 eggs/kg for 2SW salmon; 1,256 eggs/ kg for 3SW salmon; and 1,244 eggs/kg for repeat spawners. In a survey of 10 Newfoundland rivers, mean relative fecundity varied from 1,278 to 2,500 eggs/kg (O'Connell *et al.* 1997).

Natural mortality is highly variable both across and within life-stages of the Atlantic Salmon. Early survival from egg to smolt appears to be in the range of 0.03-3.0% (Chaput *et al.* 1998, Adams 2007, Fournier and Cauchon 2009, Gibson *et al.* 2009). Anadromous adult survival has been estimated in the range of 0.3-10% in recent generations (Reddin 2006, Fournier and Cauchon 2009), but reconstructions of historical runs suggest that marine survival may have been substantially higher in the past. For example, smolt-to-adult survival may have been about 15% in some Newfoundland populations when excluding marine fishery-related mortality (Dempson *et al.* 1998). This decline in marine survival has been implicated as a potentially important factor in the declines of salmon abundance.

Predation[xli]

Chaput and Cairns (2001) suggest that predation by birds and fish on drifting Atlantic Salmon eggs is a common phenomenon. The presence of salmon eggs has been reported in the stomachs of Atlantic Salmon and several other fish species (e.g., Brook Trout (*Salvelinus fontinalis*) and American Eel (*Anguilla rostrata*); Gibson 1973, Hilton *et al.* 2009).

A wide variety of predators feed on juvenile Atlantic Salmon, but predation by birds, particularly the Common Merganser (*Mergus merganser*), the Belted Kingfisher (*Megaceryle alcyon*), and the Double-crested Cormorant (*Phalacrocorax auritus*), is most widely documented (Cairns 1998, Dionne and Dodson 2002, Cairns 2006, DFO *and* MRNF 2008). Bioenergetic models estimate that Common Mergansers and Belted Kingfishers harvest 21-45% of juvenile salmon in Maritime rivers in each juvenile year (age 0+ to 2+) (Cairns 2001). In the northern portions of the species' range, the Common Loon (*Gavia immer*) may also be a significant predator of juvenile salmon, consuming substantial amounts of biomass in lacustrine systems (Kerekes *et al.* 1994). Mammals such as Mink (*Neovison vison*) and Otter (*Lutra canadensis*) prey on juvenile salmon (DFO *and* MRNF 2008), as do adult salmon (mainly non-anadromous individuals) and other fish species.

Outgoing smolts may be eaten by returning adult salmon (in marine habitat), other fish species (e.g. Striped Bass *Morone saxatilis*), mergansers, loons, gulls (*Larus* spp.), and seals (*Phoca* spp.) (DFO *and* MRNF 2008). Feltham (1995) estimated that Common Merganser predation removed 3-16% of smolt production in a Scottish river. Dieperink *et al.* (2002) tracked downstream movement of smolts in a Danish river with radio tags and determined that predation was light in the river, but was intense in the first few hours after sea entry, with major losses to gulls and cormorants. Larsson (1985) estimated that predation removed at least 50% of smolts from Swedish study sites before they reached the Baltic Sea. Higher survival (71-88%) was reported in smolts leaving Passamaquoddy Bay to the open Bay of Fundy (Lacroix *et al.* 2005). Fish known to feed heavily on salmon in estuaries, such as gadoids (Hansen *et al.* 2003), presumably also eat salmon in the open sea. Atlantic Salmon have been found in stomachs of Skate (Rajidae), Halibut (*Hippoglossus hippoglossus*), Porbeagle Shark (*Lamna nasus*), Greenland Shark (*Somniosus microcephalus*), and Pollock (*Pollachius pollachius*) (Wheeler and Gardner 1974, Mills 1989, Hislop and Shelton 1993, Hansen *et al.* 2003).

Salmon at sea may be preyed upon by Bottlenose Dolphins (*Tursiops* spp.), Belugas (*Delphinapterus leucas*) and Harbour Porpoises (*Phocoena phocoena*) (Middlemas *et al.* 2003). Seals and otters may prey on salmon in both freshwater and marine environments. In Europe, Thompson and MacKay (1999) found that 19.5% of returning salmon in northeast Scotland were scarred, but they felt, on the basis of scar patterns, that most of the damage had been inflicted by toothed whales and/or dolphins rather than by seals. Baum (1997) reported that 2% of adults returning to the Penobscot River in Maine had seal bites, and that the percent of scarred animals had risen in recent years. Avian predators, e.g. raptor species such as osprey (*Pandion haliaetus*) and bald eagle (*Haliaeetus leucocephalus*), also prey on adult salmon during migrations through estuaries and rivers (White 1939).

The Harp Seal (*Pagophilus groenlandicus*) population has increased concurrent with the salmon decline (Cairns 2001). Northern Gannets (*Morus bassanus*) from one colony (Funk Island) during one month (August) were estimated to consume 2.7% of post-smolt biomass in the NW Atlantic between 1990 and 2000 (Montevecchi and Myers 1997, Montevecchi *et al.* 2002). Gannet populations in the NW Atlantic approximately doubled between 1984 and 1999.

Physiology[xiii]

Atlantic Salmon, are ectothermic and so are dependent upon the surrounding water temperature to cue migratory patterns, to drive metabolic processes, and to determine the rate of progression from one life stage to the next (Dymond 1963, Elson 1975, Wilzbach *et al.* 1998). Water temperature (along with river discharge) is an important factor affecting returning adults during river ascent (Banks 1969). Dependent upon the location of the population, adult salmon ascend spawning streams following afternoon temperature maxima between 16°C and 26°C (Elson 1975). Optimum temperature for egg fertilization and incubation is approximately 6°C (MacCrimmon *and* Gots 1979). Most juvenile growth occurs at temperatures above 7°C (Elson 1975). The preferred or optimal summer stream temperature for the growth and survivorship of Atlantic Salmon is 17°C (Javoid and Anderson 1967), while the upper incipient lethal temperature for Atlantic Salmon is 27.8°C (Garside 1973); however, adult and juvenile salmon may live for short periods above the incipient lethal temperature (Fry 1947). A sudden increase in incipient temperature in excess of 10°C may bring about the death of resident salmon at temperatures considerably below the upper lethal temperature (MacCrimmon *and* Gots 1979).

Atlantic Salmon juveniles undergo a series of changes at approximately 2-7 years of age (generally older in the northern part of the range) and at a critical body length (varies according to location and population), which lead to outmigration (McCormick *et al.* 1998). Behavioural changes include loss of positive rheotactic behaviour and territoriality, adoption of downstream orientation and schooling tendencies (McCormick *et al.* 1998). The out-migrating period is a critical stage for imprinting to chemical signals used for homing (McCormick *et al.* 1998). The transition is cued by photoperiod and temperature, while temperature and water flow appear to be key factors regulating the timing of downstream movements (McCormick *et al.* 1998). In the ocean, salmon are found at sea in water with SSTs between 1 and 12.5°C, with peak abundance at SSTs of 6-8°C (see Marine Habitat Requirements).

Acidification is an important freshwater stressor for Atlantic Salmon in some regions (summarized in DFO 2000). Increased H+ ion concentrations coupled with the low concentrations of Ca++ are responsible for increased mortality of salmon in acidified rivers of Nova Scotia. In fresh water, the osmotic gradient results in the passive diffusion of water into the blood and of ions out of the blood. Passive losses of ions are countered by active uptake of Na+ and Cl- from the water to maintain a balanced state. When pH is ≤ 5.0, active uptake of Na+ and Cl- is reduced and passive efflux is increased resulting in a net loss of both ions. The loss of ions results in a shift of water from the extracellular fluids (e.g., plasma) to the intracellular fluids, causing a reduction in blood volume. In addition, red blood cells swell and additional cells are released from the spleen. The reduced blood volume and increased number and size of the red blood cells may cause a doubling of blood viscosity and arterial pressure. Death is a result of failure of the circulatory system. Mortality due to exposure to low pH in fresh water varies with the life stage of salmon.

All freshwater stages are unaffected when pH is above 5.4 but mortality of fry (19-71%) and smolts (1-5%) occurs when pH is below about 5.0. Mortality of parr and smolts is relatively high (72-100%) when pH declines to the 4.6-4.7 range. Eggs and alevins begin to experience lethal effects at pH's below 4.8. Levels of pH ≤5.0 also interfere with the smoltification process and seawater adaptation. Due to the natural buffering capacity of the ocean, acidification issues for Atlantic Salmon are restricted to freshwater environments.

Dispersal and migration

Given that salmon have re-colonized glaciated portions of North America since glacial retreat, it is clear that this species has some ability to disperse to new habitat. Ocean-scale migrations also suggest the potential for extremely long-range dispersal (Reddin 2006). The natal fidelity that salmon exhibit has a limiting effect on the proportion of migrants among populations. Most data suggest immigration rates for Atlantic salmon are on average 10% per river or less (e.g. Dionne *et al.* 2008, Jonsson *et al.* 2003) and below the threshold required for demographic coupling. Most straying also appears to happen relatively close to the natal rivers (Jonsson *et al.* 2003), but recent evidence suggest mixing between rivers of different regions (Dionne *et al.* 2008).

The presence of conspecifics in the destination river and the level of local adaptation may influence the success of strays. For example, return rates of stocked salmon decline as the distance between the stocked river and the source river increases (Ritter 1975). Furthermore, both natural immigrants and stocked salmon appear to have higher reproductive success when locally adapted populations are absent or suppressed (Mullins *et al.* 2003). In such cases, dispersal to new habitat and expansion of populations within freshwater systems can occur relatively rapidly (Mullins *et al.* 2003), particularly with human intervention (Bourgeois *et al.* 2000).

The migratory behaviour of both anadromous and potamodromous salmon is diverse. Some individuals move less than a few hundred metres their entire lives (Gibson 1993), some populations complete short migrations to estuaries or along the nearby coast, and many populations complete ocean-scale migrations (Reddin 2006). The migratory routes taken by individual populations may have some genetic basis (Reddin 2006), but even within populations there may be variability in migratory timing and route (Klemetson *et al.* 2003). This heritable migratory behaviour is likely due, at least in part, to local adaptation, meaning immigrants may be at a disadvantage compared to locally adapted residents, as suggested by Dionne *et al.* (2008) for Atlantic Salmon and Tallman and Healey (1994) and Hendry *et al.* (2000) for other salmonids.

Interspecific interactions[xiv]

Atlantic Salmon juveniles are territorial and year-class abundance declines over time as a result of competition for resources (Chaput 2001). Atlantic Salmon in fresh water compete for resources with conspecifics and potentially with other species, particularly other salmonids. Juvenile Atlantic Salmon are opportunistic predators of aquatic invertebrates (Gibson 1993), especially those drifting at the surface. Body size is the prime determinant of Atlantic Salmon territory size and, though environmental factors such as food availability may influence territory size, the degree of influence is first 'filtered' through an individual's requirement for space (Grant *et al.* 1998). As such, competitors that exclude Atlantic Salmon from rearing habitat or use other resources of their freshwater environment will negatively affect Atlantic Salmon.

In some parts of the Atlantic Salmon's range (particularly Newfoundland, Labrador and Quebec; Scott and Crossman 1973), non-anadromous forms of Atlantic Salmon occur in sympatry with anadromous runs. In some cases these life history variants are genetically distinct from anadromous individuals while in others there is no genetic divergence (Adams 2007). Non-anadromous juveniles are phenotypically indistinguishable from their anadromous counterparts and likely occupy similar niches at the expense of anadromous conspecifics.

Where Atlantic Salmon are sympatric with native Brook Trout, salmon displace trout from riffle habitat but may be at a competitive disadvantage in pools (Gibson 1993). Gibson and Dickson (1984) found that Atlantic Salmon juveniles showed enhanced growth in an otherwise fishless area of boreal Quebec, and also in a stream from which Brook Trout had been removed. However, density and biomass relationships between Brook Trout and Atlantic Salmon were not detected across several watersheds in another area of Newfoundland (Cote 2007). Similarly, no significant relationships between survivorship of Atlantic Salmon fry and abundance of Brook and Rainbow Trout were detected in streams of Vermont. Instead, fry survival was, in part, positively related to abundance of Brook Trout parr (Raffenberg *and* Parrish 2003).

Interactions between Atlantic Salmon and salmonids not native to eastern North America have also been studied. Rainbow Trout (*Oncorhynchus mykiss*), native to the Pacific coast, now occur in many Atlantic Salmon rivers and are expanding their range in some areas (e.g. Newfoundland; Porter 2000). While the two species demonstrate some degree of habitat overlap, and engage in some interspecific competition (Fausch 1998), juvenile Atlantic Salmon are more closely associated with positions near the substrate (riffle areas) and Rainbow Trout with the water column (or pool habitats) (Hearn and Kynard 1986, Volpe *et al.* 2001). Recent research conducted in Lake Ontario streams also suggests that Atlantic Salmon and Rainbow Trout juveniles can coexist successfully in streams where the habitat is suitable for both species (Stanfield and Jones 2003). Outcomes for salmon resulting from these interactions are often situation-specific, as habitat conditions (Jones and Stanfield 1993), dominance behaviour (Blanchet *et al.* 2007) and prior residence come into play (Volpe *et al.* 2001). Blanchet *et al.* (2008) suggested that increased daytime activity in the presence of juvenile Rainbow Trout might increase predation risk for juvenile Atlantic Salmon.

Two other Pacific-origin salmonids, Chinook Salmon (*Oncorhynchus tshawytscha*) and Coho Salmon (*Oncorhynchus kisutch*), occur in the Great Lakes. High densities of stocked Chinook Salmon have potential to negatively affect Atlantic Salmon behaviour and survival (Scott *et al.* 2003) and interfere with spawning behavior (Scott *et al.* 2005). Similarly, Coho Salmon can affect growth and survival (Jones and Stanfield 1993); however, they are much less likely to have significant impacts due to relatively low abundance and different habitat requirements (Stanfield and Jones 2003).

Atlantic Salmon and Brown Trout (*Salmo trutta*) interactions are relatively well studied. The Brown Trout, a native of Europe, has been introduced to numerous North American systems used by Atlantic Salmon and appears to be expanding its range in Newfoundland (Westley *et al.* submitted). Brown Trout tend to use the margins of runs and pools where water velocity is lower, in contrast to riffle specialization by Atlantic Salmon (Fausch 1998, Bremset and Heggenes 2001, Heggenes *et al.* 2002). Gibson and Cunjak (1986) reported that introduced Brown Trout in the Avalon Peninsula, Newfoundland, were largely segregated from Atlantic Salmon by habitat choice and to some degree, by food habits. Nevertheless there is overlap in types of habitat used by the two species (Heggenes and Dokk 2001). The occurrence of competition between

Brown Trout and Atlantic Salmon is not universal (e.g. Gibson and Cunjak 1986) and appears to be scale-dependent (sample resolution of studies reporting competition are generally <100 m^2; Westley *et al.* submitted). Negative impacts include competition for females, winter shelter (Harwood *et al.* 2002a,b) and spawning habitat, and genetic and survival repercussions associated with hybridization between Brown Trout and Atlantic Salmon (Gephard *et al.* 2000). Competition between these species is most intense at spawning and early juvenile stages (Westley *et al.* submitted). In general, seemingly contradictory results suggest that the view that competition forces an inverse relation between other salmonids and Atlantic Salmon populations may not be tenable at all geographic scales (Cairns 2006).

There are several other non-indigenous species of freshwater fish that have become established in many watersheds containing wild Atlantic Salmon. The species of most concern include Smallmouth Bass (*Micropterus dolomieu*), and species in the pike family: Chain Pickerel (*Esox niger*) and Muskellunge (*Esox masquinongy*). These species are potentially both competitors and predators of juvenile Atlantic Salmon. Introductions are generally the result of directed and illegal transfers of live fish between watersheds. The introduction of non-native species into existing salmon habitat represents a real and expanding threat to the persistence of salmon in the affected and adjacent drainages (DFO and MRNF 2009).

Correlations between survival and growth during first summer/winter at sea suggest food resources may be a limiting factor during some marine phases (Peyronnet *et al.* 2007). However, variable environmental conditions in the ocean, rather than competition-induced shortages, are provided as explanations driving marine growth (Peyronnet *et al.* 2007). Examinations of smolt output and sea survival suggest these two parameters are not linked (Gibson 2006, Reddin 2006) and provide indirect evidence that competition in marine waters is relatively unimportant for Atlantic Salmon. Unfortunately, the vast scale of the Atlantic Salmon's ocean habitat precludes field experiments to directly measure competitive interactions of Atlantic Salmon with other species (Cairns 2006).

Interactions with prey species in the marine environment may also play an important role in marine survival. Studies from the eastern Atlantic show Atlantic Salmon prey on a variety of taxa including, but not limited to: Atlantic Herring (*Clupea harengus*), Capelin (*Mallotus villosus*), Sandeels (Ammodytidae), Gadids, Lantern Fishes (Myctophidae), Barracudinas (paralepidids), various invertebrates (amphipods, copepods, euphausids and crustaceans (shrimps)) (Haugland *et al.* 2006). Atlantic Salmon appear to focus on invertebrates early in their marine phase, but fishes appear to become a more important diet item as salmon grow older and larger (Reddin 1988, Hislop and Shelton 1993, Hansen and Quinn 1998). The diet of Atlantic Salmon in the marine environment is variable both temporally and spatially, suggesting they feed opportunistically as they migrate. This variability in diet makes it difficult to link marine growth and survival to the abundance of specific prey species.

Numerous disease-causing agents have been identified in wild Atlantic Salmon (Bakke *and* Harris 1998). These include *Renibacterium salmoninarium* (bacterial kidney disease (BKD) causing agent), *Aeromonas salmonicida* (furunculosis), infectious pancreatic necrosis virus, *Vibrio anguillarum* and *Edwardsiella tarda* (DFO 1999). There is documented history of some of these diseases in Maritime rivers including furunculosis and BKD (Cairns 2001). Furunculosis can become an important factor in adult in-river survival especially during periods of low flow and warm water. A new disease agent, infectious salmon anemia virus (ISA), was discovered in aquaculture-reared fish in 1997 (DFO 1999). Myxozoa species (likely introduced) have also been reported in juvenile Atlantic Salmon from several Canadian rivers (Dionne *et al.* 2009b).

Within Lake Ontario, recent emergence of viruses new to the Lake Ontario basin have the potential to cause disease and mortality in wild Atlantic salmon (e.g. Viral Haemorrhagic Septicaemia (VHS) detected in 2005). Additionally, salmonid species in Lake Ontario are carriers of the bacteria known to cause bacterial kidney disease (BKD). Atlantic Salmon strains currently being reared to support Lake Ontario restoration efforts are susceptible to disease outbreaks and seasonal mortality when infected with these bacteria.

Adaptability

Atlantic Salmon exhibit a wide range of variation in both phenotypic plasticity and adaptive genetic variation across its range (Taylor 1991, Gibson 1993, de Leaniz *et al.* 2007). From individuals that spend their entire life cycle within a few metres of the natal stream and attain a size of < 10 cm, to 100+ cm individuals that undertake ocean-scale migrations, it is clear that this species has the capacity to adapt to a wide variety of conditions on relatively short demographic and evolutionary scales (Gibson 1993). However, while Atlantic Salmon appear to be flexible within the natural range of variation for freshwater habitat in eastern Canada, the species does not appear to adapt well to major anthropogenic disturbances. In particular human activities that interrupt migratory behaviour (e.g., dams), or drastically impact water quality (e.g., acidification) have led to extirpations in the past (Amiro 2003).

This species adapts well to domestication as is evident in the global aquaculture industry. Recent studies suggest that salmon show a selection response to domestic conditions within a single generation. Unfortunately, rapid selection under domestic conditions can create challenges when attempting to supplement natural populations with hatchery-raised fish. Genetic data suggest that stocked fish have often had limited reproductive success (e.g., Fontaine *et al.* 1997, Saltveit 2006). Transplants of wild stock have been relatively rare. However, there have been documented successes (e.g., Rocky River in DU 4) (Bourgeois *et al.* 2000), usually within a short geographic distance between source and destination sites and into habitats devoid of naturally occurring anadromous populations. Transplanting salmon among DUs may be more difficult due to a higher probability of maladaption. For example, Ritter (1975) showed declining return rates of stocked salmon as the distance to the source population increased. de Leaniz *et al.* (2007) recently reviewed much of the evidence for local adaptation and the role it plays in Atlantic Salmon fitness and ultimately population dynamics. The authors concluded that while local adaptation is likely important, quantitative evidence of its role in processes such as migratory timing, disease resistance or growth rate are scarce.

POPULATION SIZES AND TRENDS

The data compiled for the analysis of all Canadian DUs were provided by the Canadian Department of Fisheries and Oceans and the Quebec Ministère des Resources naturelles et de la Faune. Spawning escapement estimates (the number of fish available to spawn each year after all fisheries have taken place) were used throughout the trend analysis. Escapement was chosen over pre-fishery abundance based on COSEWIC criteria to use "mature individuals who are capable of reproducing". Within COSEWIC, definitions of mature individuals are further defined as follows: "Mature individuals that will never produce new recruits should not be counted". Assuming a significant proportion of the salmon captured historically in commercial and recreational fisheries would have reproduced, the use of spawning escapement data in trend analysis would, relative to the abundance of fish before the fisheries occur, will underestimate the extent of decline in several DUs (compare the trends shown in Figures 13 and 14). However, when spawning escapement is used for the trends analysis, the effectiveness of management actions such as fishery closures (described in the next section) is taken into account in the analysis. Canadian abundance reconstruction suggests significant declines in pre-fishery abundance across all DUs and the North American population as a whole (Chaput 2009; Figure 14). This decline appears to have stabilized in most northern regions during the last 3 generations (DUs 1-3, 5-7), but not in the south.

The analysis of population trends was standardized to provide consistent assessments across DUs. Catch data were used primarily in the analysis despite the potential error associated with these types of data (O'Connell 2003) as it was widespread and common to most areas. These data do, however, carry significant risk and uncertainty. O'Connell (2003) demonstrated that major differences can occur when using recreational catch data to infer total returns. He showed that in one case returns were overestimated by approximately 60% in four of seven years. A review of the status of salmon (Dempson *et al.* 2006) stated that stocks for which only angling data were available are not routinely evaluated, in the Newfoundland-Labrador region. Reasons for this included changes in daily and season bag limits, the introduction of split seasons and quotas in some areas in some years, the switch from DFO Guardian-provided recreational catch data to that obtained from a licence stub return system, the complexities and confusion of interpreting catch-and-release statistics over the years, and the fact that in some areas and years 35-65% of all potential fishing days may be unavailable owing to environmental closures. O'Connell *et al.* (1998) also showed there could be substantial differences between angling data derived from the licence stub system versus that provided by DFO Guardians for years when the two methods overlapped. This depended on the year and area in question, and was much more pronounced for released fish rather than retained salmon. Despite these well-documented potential problems these were the only data available for all DUs that would allow nation-wide comparison. In some areas, data were limited (e.g. DUs 1 and 2) and/or better info was available (DUs 13, 14). Details on sampling effort and data quality issues are provided for each DU. River-specific trend data from other sampling methods are presented graphically where available. Where the catch data trends diverge from river-specific data, the differences are noted in the DU text.

COSEWIC specifies time frames of 10 years or three generations (whichever is longer) in the examination of population trends. The complex and variable life history of Atlantic Salmon results in different generation times within and among rivers. A DU-specific generation time was determined by averaging the modal smolt age for the rivers presented in Chaput *et al.* (2006a)[xv] and adding 1 or 2 years for the marine phase of life, depending on whether MSW fish were common in the specific DU. This approach would slightly underestimate generation time in populations where repeat spawning frequency is high. Smolt ages were typically consistent or within one year of other rivers within a DU. Abundance trends were analyzed using a time series for which the length was determined by multiplying the generation time by three and roughing up to the whole number. For example, if the generation time was 4.1 years, the trend was analyzed over 13 years.

Abundance trends were assessed with a general linear model using a negative binomial error distribution (all statistics computed using R; R Development Core Team (2007)). Values for the calculation of percent change in abundance were taken from the predicted values of the general linear model (latest year and that from 3 generations previous). These estimates of change isolate temporally driven change and are more robust to spurious results. The statistical significance of the estimates trends was assessed at the 95% confidence level. Forward projections have not been provided due to the known dangers of predicting outcomes beyond the range of the data collected. They would also require unrealistic assumptions of static conditions and the absence of abundance-dependent phenomena such as depensation (which would hasten the decline) or compensation (which would slow or halt the decline). Because significant declines have occurred during the last four decades (Reddin 2010; Figure 14), and because for some DUs, the inclusion of just one extra generation resulted in significant trends that were not detected in analyses using three generations, where available longer time series are presented graphically for each DU.

The estimate of abundance for Canada is based on the sum of all DU-specific data and should be considered a minimum value as full abundance estimates were not available for DUs 1, 13 and 14. The 'complete' data set spans 1993-2007. The Canadian estimate of abundance of spawning, wild adult Atlantic Salmon was 524,288, in 2007. Of these 414,163 were small salmon and 110,154 were large salmon. Where data were available, 2008 appeared to have improved returns versus 2007. The lowest estimate over the data set was 364,373 in 1994 while the highest was 611,405 (1996). Overall, the model-based estimate of total abundance appears to have increased slightly since 1993 (by 11%), but the trend in the data was non-significant ($P = 0.41$; Figure 15). Small salmon abundance has increased by 19% from 1993 levels, while large salmon abundance has decreased by 14% of 1993 levels. Neither trend was significant over three generations ($P = 0.246$ and 0.136 respectively). However, within this broad assessment there are population components and regions that are experiencing significant declines (i.e., MSW salmon and DUs 4, 8, 9, 14, 15, 16; Table 2) or are extinct (DU 11[xvi]). Regions at the southern extent of the Canadian range (Nova Scotia Southern Upland, DU 14; inner and outer Bay of Fundy, DUs 15 and 16) have undergone marked declines. Trends from individual DUs suggest that small and large salmon may be on differing trajectories of abundance, although neither trend is significant at the Canadian scale in the last three generations. Reddin and Veinott (2010) also suggest that small salmon are increasing in abundance while large salmon are declining. The analysis used in this report was applied to the data for Newfoundland and Labrador, presented by Reddin and Veinott (2010) and Reddin (2010), and it was determined that the increasing trend in small salmon abundance was marginally significant ($P = 0.061$) and the declining trend in large salmon abundance was highly significant ($P < 0.001$). The overall trend for total salmon was not significant ($P = 0.302$). Large salmon have declined to 59% of 1993 levels. The divergent trends for MSW and 1SW salmon abundance are difficult to explain, but the data suggest that the risk of extended periods at sea may be relatively higher than it was historically. Repeat spawners (with the exception of DUs 14-16) have experienced improved survival in recent years (e.g. Cameron *et al.* 2009).

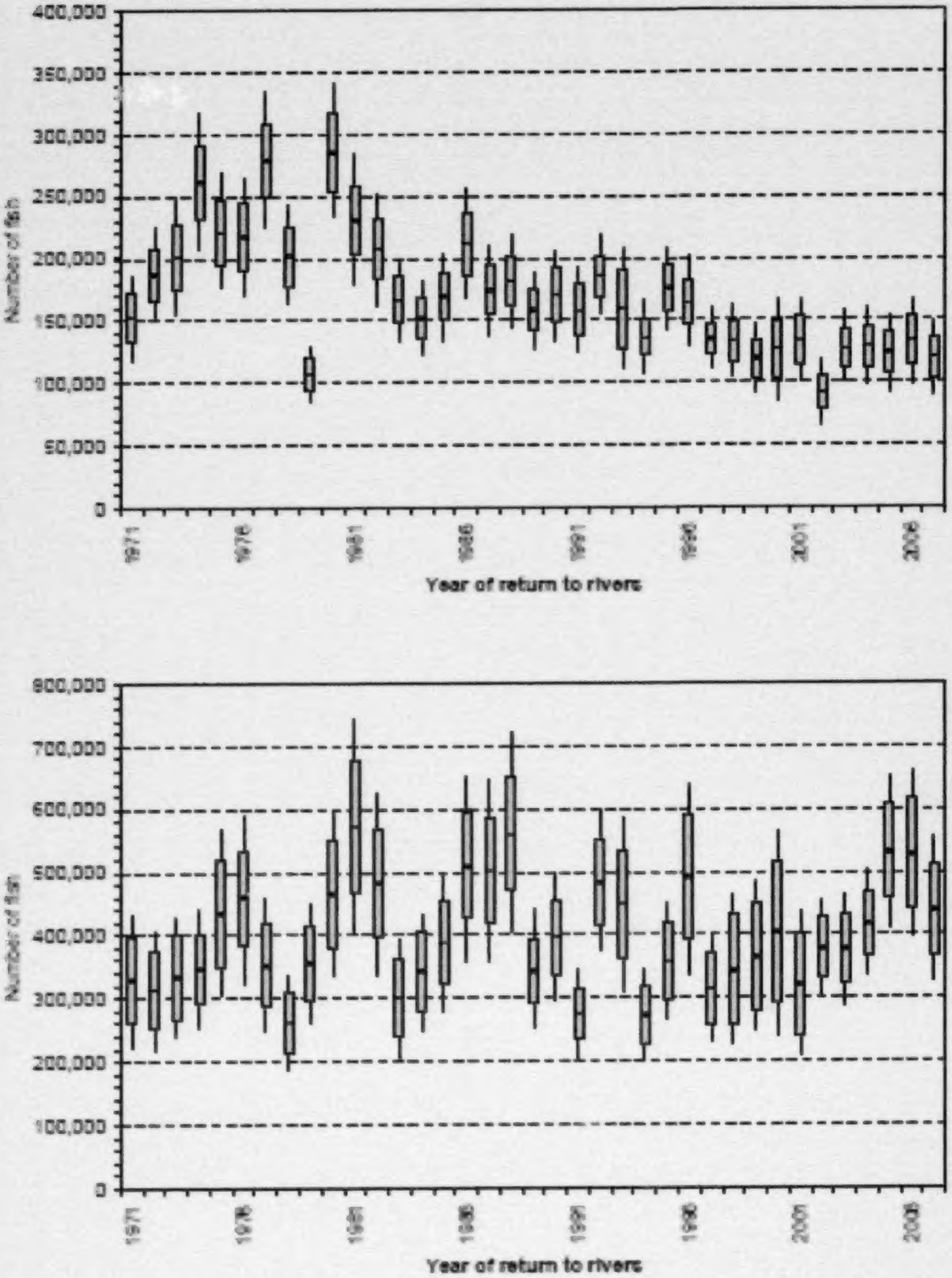


Figure 13. Posterior distributions from Monte Carlo simulation of estimated returns to the rivers/coast (after sea fisheries of Newfoundland and Labrador and St. Pierre and Miquelon) of large salmon (upper) and small salmon (lower) for eastern North America, 1971 to 2007. Box plots are interpreted as follows: dash is the median, rectangle defines the 5th to 95th percentile range, vertical line indicates minimum and maximum values from 10,000 simulations (taken from Chaput 2009).

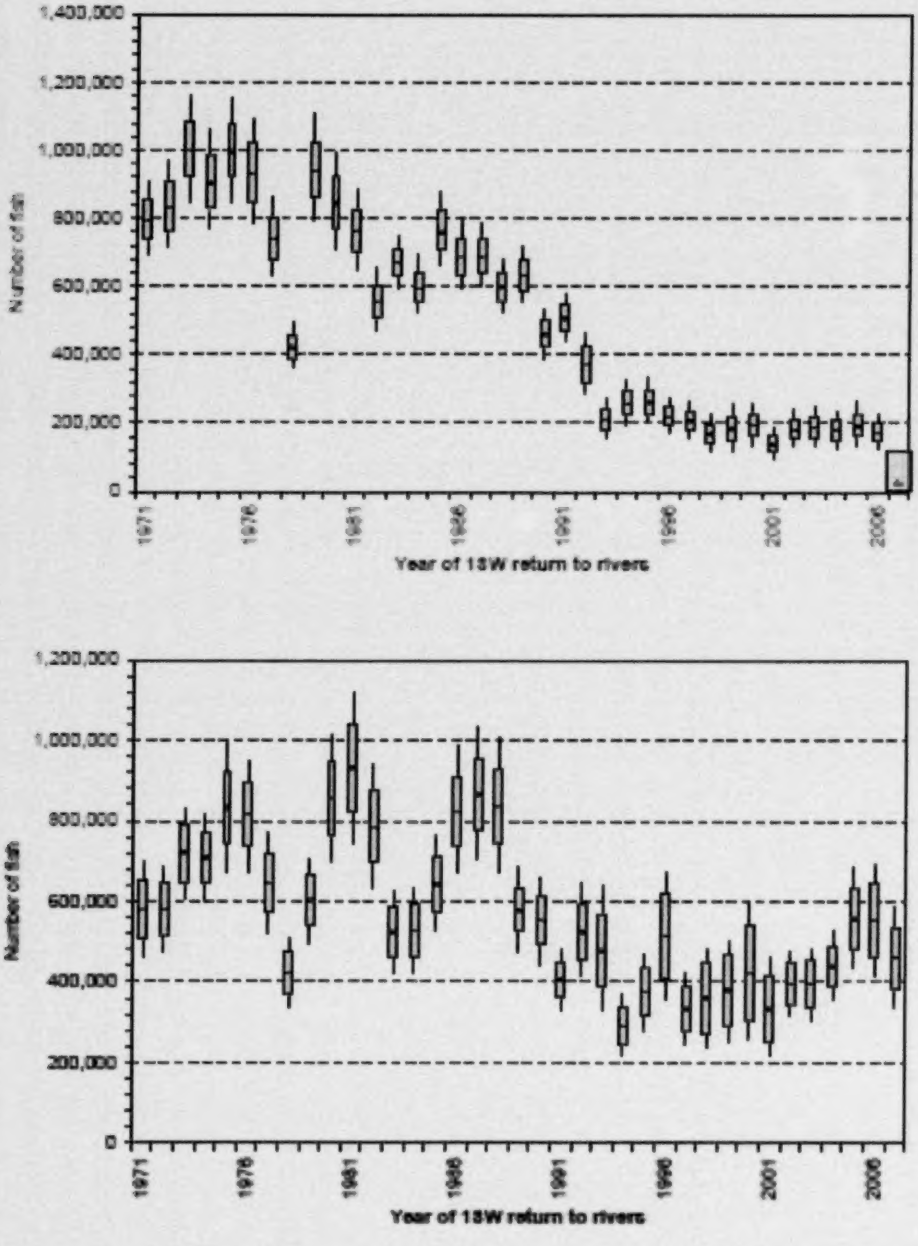


Figure 14. Posterior distributions from Monte Carlo simulation of estimated pre-fishery abundance of large salmon (upper) and small salmon (lower) from eastern North America, 1971 to 2007. Pre-fishery abundance for large salmon is only available to the 1SW year of 2006. Box plots are interpreted as follows: dash is the median, rectangle defines the 5th to 95th percentile range, vertical line indicates minimum and maximum values from 10,000 simulations (taken from Chaput 2009).

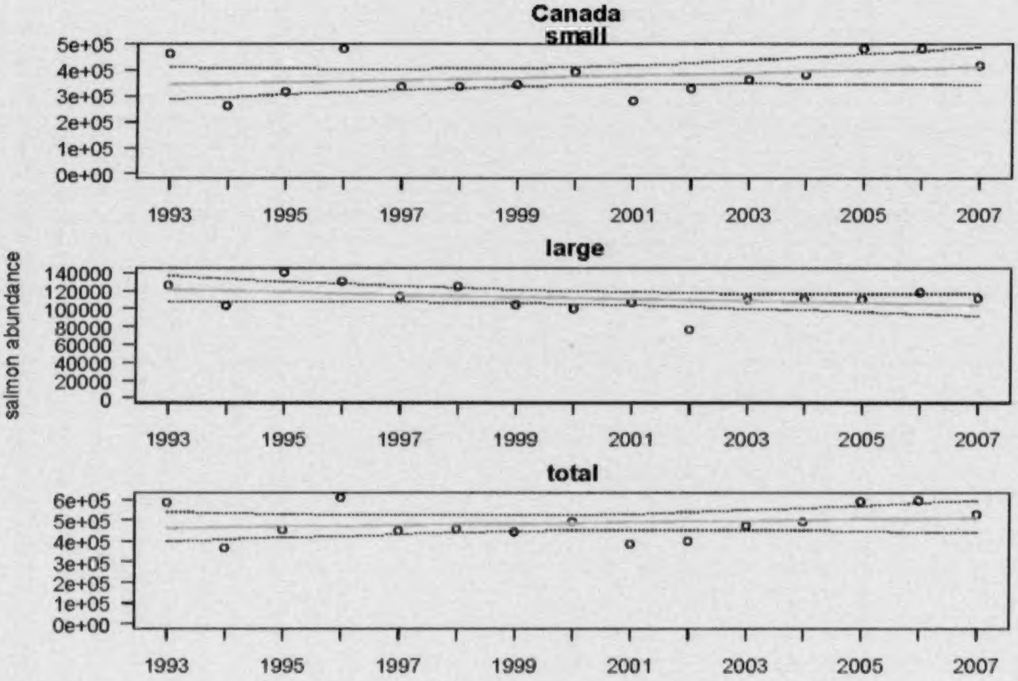


Figure 15. Small, large and total Atlantic Salmon escapement for Canada (small: top panel; large: middle panel; total: bottom panel) over the past 3 generations (15 years). Superimposed is the general linear model (+/- 2SE prediction intervals) used to determine trends in abundance.

Fisheries management[xvii]

The abundance of Atlantic salmon in Canada has been significantly influenced by fisheries management policy. To provide further context, a brief overview of fisheries management is presented.

As early as the 1970s, fisheries managers began placing restrictions on commercial Atlantic salmon harvests to replenish depleted stocks (May 1993). When pronounced declines in abundance were observed in the 1980s, a wide range of additional management measures were introduced for conservation purposes. The closures of commercial fisheries were expanded in 1984 to include all the commercial fisheries of the Maritime Provinces and portions of Quebec. Further reductions were introduced through the late 1980s and early 1990s, leading to a moratorium on commercial Atlantic Salmon fishing for insular Newfoundland in 1992, followed by a moratorium in 1998 for Labrador, and culminating with the closure of all commercial fisheries for Atlantic Salmon in eastern Canada in 2000.

In 1984, mandatory catch and release in recreational fisheries of all large Atlantic Salmon was introduced in the Maritime Provinces and insular Newfoundland. Since then, more restrictive angling management measures have been introduced in an attempt to compensate for declining survival and Atlantic Salmon abundance, including reduced daily and season bag limits, mandatory catch and release of large and in some cases all sizes of Atlantic Salmon, and in large portions of the Maritimes, the total closure of all directed fisheries.

The need for increasingly severe restrictions on harvests over the past decades reflects the chronically unrealized expectations of Atlantic salmon stock recovery. Though population increases did occur, they were often short-lived (e.g. Dempson *et al.* 2004). Over longer terms, harvest restrictions in most DUs have generally contributed to the stabilization of declining populations or slowed declines (the exceptions being DUs 2 and 5). As stated previously, the positive contributions of these management restrictions may have had the effect of lessening the degree of reduction in the productive capacity of Atlantic salmon populations, as indicated by spawning escapement indices, but could mask the actual decline in overall abundance of salmon based on the indicators of total returns or pre-fishery abundance.

Table 2. Trends in Atlantic Salmon spawner abundance for designatable units of eastern Canada. Probability values associated with inferred trends are given in parentheses. Note that DUs annotated with asterisks reflect abundance estimates for a subset of rivers. DD - Data Deficient.

Designatable Unit	Recent Abundance (Year)	Small Salmon % change over 3 generations (p-value)	Large Salmon % change over 3 generations (p-value)	Total Salmon % change over 3 generations (p-value)
1 - Nunavik	DD	DD	DD	DD
2 - Labrador	235,064 (2008)	+443.9 (<0.001)	+127.9 (0.016)	+380 (<0.001)
3 - NE Newfoundland	80,505 (2007)	-11.0 (0.569)	+1.7 (0.946)	-9.6 (0.619)
4 - S Newfoundland	21,866 (2007)	-37.3 (0.063)	-26.2 (0.293)	-36.1 (0.071)
5 - SW Newfoundland	44,566 (2007)	+132.1 (<0.001)	+143.7 (<0.001)	+133.6 (<0.001)
6 - NW Newfoundland	31,179 (2007)	-4.2 (0.838)	+41.7 (0.126)	0.0 (0.999)
7 - Qc E North Shore	5,901 (2008)	-26.3 (0.0.085)	50.8 (0.115)	-13.79 (0.287)
8 - Qc W North Shore	15,135 (2008)	-34.0 (0.031)	-20.1 (0.143)	-24.4 (0.013)
9 - Anticosti Island	2,414 (2008)	-31.7 (0.076)	-48.7 (0.017)	-40.2 (0.007)
10 - St. Lawrence	4,169 (2008)	-1.8 (0.951)	+11.5 (0.429)	+5.27 (0.772)
11 - Lake Ontario	Extinct[1]	-	-	-
12 - Gaspé-Gulf	103,149 (2007)	-34.0 (0.119)	-18.5 (0.217)	-27.8 (0.100)
13 - E Cape Breton*	1,150 (2008)	-7.9 (0.789)	-14.5 (0.542)	-28.9 (0.202)
14 - NS Southern Upland*	1427 (2008)	-58.6 (0.002)	-74.0 (0.001)	-61.3 (<0.001)
15 - I Bay of Fundy	<200	-	-	-
16 - O Bay of Fundy	7584 (2008)	-56.6 (0.024)	-81.6 (<0.001)	-64.3 (0.001)

[1] Currently assessed as Extirpated (COSEWIC 2006a); however, this report proposes that it be revised to Extinct, in keeping with the implication of the current COSEWIC guidelines for recognizing DUs, that loss of an entire DU represents an extinction event, not an extirpation.

Designatable Unit 1 – Nunavik

Data were limited to the sporadic angling effort and catch statistics for Ungava Bay (MRNF 2009, MRNF unpublished data). The limitations of these data restricted the analysis to assessment of catch per unit effort (CPUE). As with all fishery-dependent data, the assumptions of constant catchability of the salmon and the equivalence of effort over the data set are likely to be violated. However, given that the fishery is limited to angling, changes in fishing gear and techniques are less of a factor than in commercial fisheries. Unfortunately, catchability of Atlantic Salmon is heavily influenced by water conditions. Angler data are the only type consistently available for almost all salmon populations, thus a broad assessment requires its utilization.

The data for Ungava Bay was from four of the five known salmon rivers during the time period 1984 – 2008. Mean rod-days per year was 1,014 with a range of 415-1,615. Effort has generally been declining over the time series. No estimate of abundance could be calculated. There also was a significant increasing trend in CPUE over the time series (GLM on catch with effort offset: $P=0.007$). While the data only include four rivers with commercial angling activities, salmon have been reported from other rivers in this DU. The George River and the Koksoak River had substantially higher CPUE estimates than the Feuilles and Baleine rivers, suggesting higher abundances over the time series. There have been no known extirpations in this area.

Designatable Unit 2 – Labrador

Data for the Labrador DU were diverse. There were commercial catch data (1969-2001) (Reddin 2010) and count data from four counting fences (2002-2008). These data were used in conjunction with habitat data to estimate abundance per habitat unit over time, which was then scaled up for the whole region, which includes 85 Labrador salmon rivers (Reddin 2010). The five rivers from Quebec that are part of DU 2 have spawner abundance time series, based on catch data, that were added to the Labrador data to derive an abundance time series for the entire DU.

There is considerable uncertainty associated with these data since it assumes the four index rivers in southern Labrador are representative of a huge geographical region (scaling from ~1,700 to 65,500 km^2), which includes varying intensities of Aboriginal fishing and habitat quality. Furthermore, information from Quebec rivers is based on angler data (MRNF 2009, MRNF unpublished data) and habitat scaling (Caron and Fontaine 1999) that are also characterized by considerable uncertainty.

The most recent estimate of adult abundance for DU 2 is 235,064 with 206,093 being small salmon (<63 cm) and 28,970 being large salmon (>63 cm). The lowest abundance during the last three generations was 30,555 in 1991. The highest abundance over the same time frame was 242,758 in 2005. During the last three generations there have been significant increases in abundance of small ($P<0.001$), large ($P=0.016$) and total salmon ($P<0.001$) (Figure 16). The abundance of small salmon (based on the curve fit in Figure 16) is 443.9% greater than the 1990 abundance while large salmon abundance is up by 127.9% over the same period. Total salmon are at levels 330.0% of those in 1990 (Figure 16). Data for counting fence facilities in DU 2 (English River, Muddy Bay Brook, Sandhill River and Southwest Brook) are provided in Figure 17. Additional river-specific abundance data are provided in Appendix 1 (see Big Brook, Pinware, Forteau and du Vieux Fort rivers).

As with all following DUs (except DU 11), it should be noted that using statistics of adult salmon spawners as a measure of population health has the disadvantage of potentially masking the severe declines observed in pre-fishery abundance. In this case, when commercial fishery-related mortality is accounted for, current levels of salmon abundance in DU 2 are much lower than expected (Reddin 2010).

The only known population to be lost from this DU was Bobby's Brook, located near the Alexis River. There has been no evidence of re-colonization of this tributary to date (D. Reddin, Dept. of Fisheries and Oceans, pers. comm.).

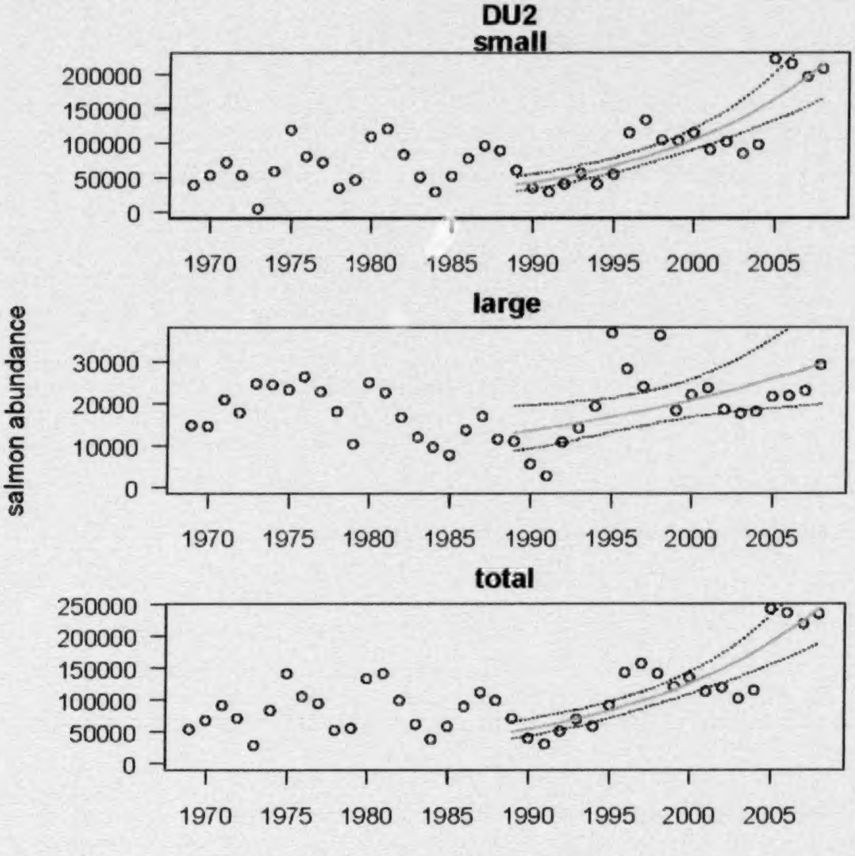
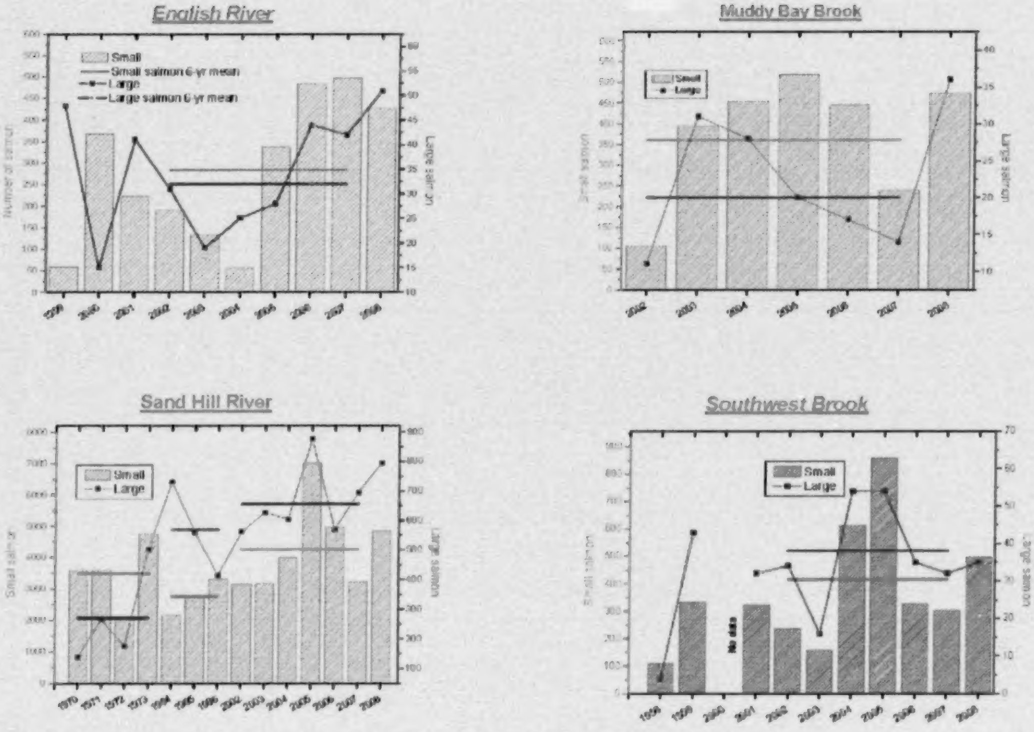


Figure 16. Atlantic Salmon escapement (small: top panel; large: middle panel; total: bottom panel) for DU 2 (1969-2007). Superimposed is the general linear model (+/- 2SE prediction intervals) used to determine trends in abundance over the past 3 generations. Note that pre-1984 data for Quebec components of DU 2 were unavailable and are not included in this plot. Since 1984, the Quebec component only contributed an average of 4% of the run (range: 1-12%).



English River

Muddy Bay Brook

Sand Hill River

Southwest Brook

Figure 17. Salmon abundance in four index rivers in Southern Labrador (taken from Reddin 2010). Note that the time periods are not identical among the panels and that the Sand Hill data include breaks in the time periods.

Designatable Unit 3 – Northeastern Newfoundland

The data available for DU 3 consists of angler (1969-2007) and commercial (1969 – 1992) catch data, and counts from 6-8 counting fences (mean of 7 per year). Estimates of abundance for the entire DU were calculated based on angler catch and effort data, adjusted for catch rates based on data from rivers with counting fences (Reddin and Veinott 2010, but see O'Connell 2003). Rivers with no angling catch were not included in the abundance estimates provided. Another challenge with these data is the large increase in abundance of salmon in the enhanced Exploits River, where extensive unused habitats were made available (Mullins *et al.* 2003). In some years, the Exploits and Gander rivers can account for nearly half the population of this DU and this swamping effect should be considered when examining trends for DU 3.

DU 3 has 127 documented salmon populations, with a substantial number of small streams that appear to have transient populations (juveniles are always present but adults return sporadically; C. Bourgeois, Dept. of Fisheries and Oceans, pers. comm.). The most recent estimate of adult abundance for DU 3 is 80,505 (51,883-109,267) from 2007, with 68,654 being small salmon, and 11,851 being large salmon[xviii]. The lowest abundance during the last three generations was in 2002 with 58,584 (Figure 18). The highest abundance during the last three generations was 141,968 in 1996. There were no significant trends in abundance for small, large or total salmon for this DU over the last three generations (P = 0.569, 0.947, and 0.618 respectively). The abundance of total salmon has declined by 9.5% over this time period (based on the curve fit in Figure 18), while small are 9.6% less abundant than three generations ago in 1994 (Figure 18). Large salmon abundance is estimated to have increase by 1.7% during this time period. As in Labrador, the non-significant trends in abundance, presented here for the past three generations, seem incomplete without considering the effects of commercial fishery closures that occurred in 1992 and remain in effect now. The returns data presented here do not include the commercial removals that were very high in the years up to 1991 (Reddin and Veinott 2010). Inclusion of these data is problematic because the landings include some salmon not originating from rivers within the DU. Reconstruction of pre-fishery abundance paints a picture of a substantial decline that has stabilized during the past 3 generations (DFO 2008). Additionally, more recent runs have not met increased expectations associated with improving escapement levels post-moratorium. Freshwater productivity has remained stable (DFO 2008) and there have been no reported extirpations of salmon in DU 3. Data from individual rivers monitored with counting fences (Exploits River, Gander River, Middle Brook, Terra Nova River and Campbellton River) are provided in Figure 19. Supplementary abundance data (for Indian Bay Brook, Northwest River and Indian River) are provided in Appendix 1.

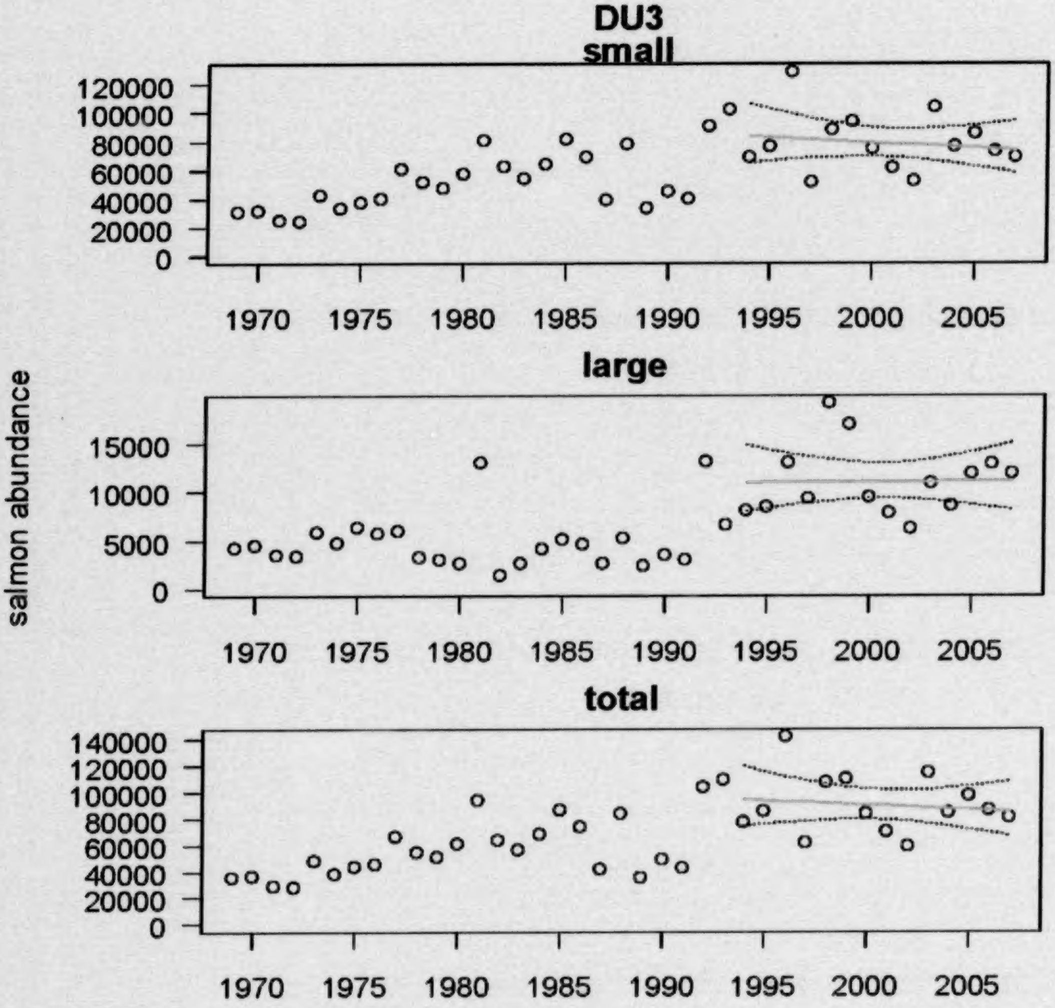


Figure 18. Atlantic Salmon escapement (small: top panel; large: middle panel; total: bottom panel) for DU 3 (1969-2007). Superimposed is the general linear model (+/- 2SE prediction intervals) used to determine trends in abundance over the past 3 generations.

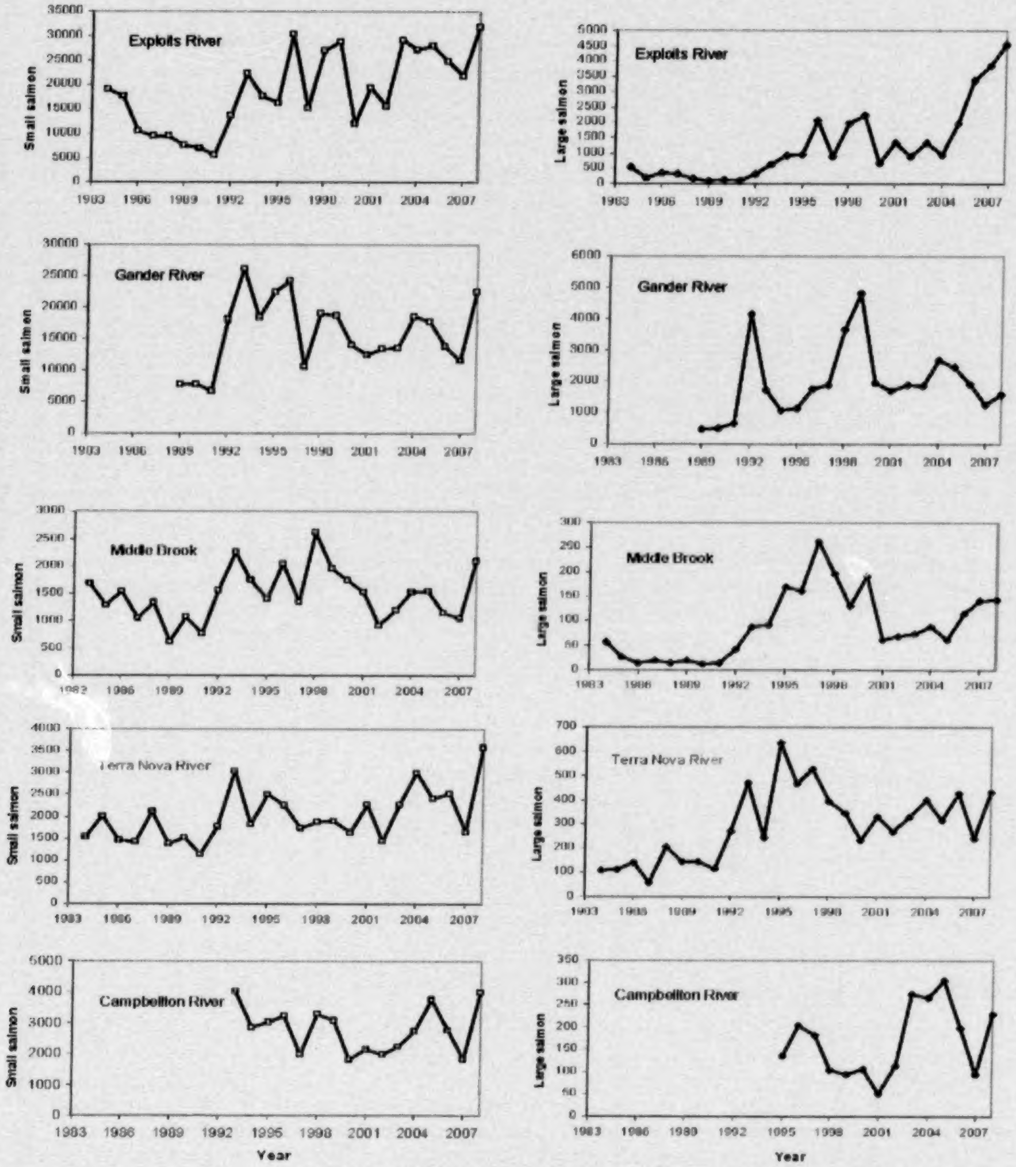


Figure 19. Small (left panels) and large (right panels) salmon abundance from counting fence facilities (Exploits, Gander, Middle, Terra Nova and Campbellton) of DU 3 (taken from Reddin and Veinott 2010).

Designatable Unit 4 – South Newfoundland

The data available for DU 4 consisted of angler (1969-2007) and commercial (1969 – 1992) catch data, and counts from 5 counting fences (mean of 4 per year) (Reddin and Veinott 2010). Angler catch data was based on a mean estimate of 20,527 rod days per year with a range of 12,208 – 32,642. There are 104 known rivers in this DU, with no known extirpations and one introduced population (Rocky River). Conne River had the highest estimated abundance over the time series, peaking at just over 10,000 returning adults. Most rivers in this DU appear to have mean abundances of less than 500 spawning adults (Dempson *et al.* 2006). Angling effort has declined by nearly 50% over the last 15 years. Estimates of abundance for the DU were calculated based on angler catch and effort data, adjusted using the catchability data from the rivers with counting fences (Reddin and Veinott 2010). The fishery-independent data from this DU are heavily biased to the eastern side of the DU and may not be representative of the entire DU. Furthermore, rivers with no angling catch were not included in the abundance estimates provided.

The most recent estimate of adult abundance for DU 4 is 21,866 (14,021-29,711) from 2007, with 18,633 (12,411-24,854) being small salmon, and 3,233 (1,610-4,857) large (Figure 20). The lowest abundance during the last three generations was in 2001 with 18,409. The highest abundance during the last three generations was 60,008 in 1996. The abundance of small salmon (based on the curve fit in Figure 20) declined by 37.3% since 1994. The abundance of large salmon has declined by 26.2% since 1994, and total salmon abundance has declined by 36.0% (Figure 20). Estimated declines in the abundance of small and total salmon are marginally insignificant ($P = 0.063$ and 0.071 respectively), but the estimated decline in large salmon abundance is not significantly different from zero ($P = 0.293$). It is worth noting that while trends in abundance were similar between catch data and counting facility data for this DU, the counting facility data and total catch information suggest that 2007 was the lowest year on record not 2001. Additionally, these decline rates are sensitive to the length of the time series used. Extending the time series back one additional year yields decline rates of 52.5% and 50.1% for small and total salmon respectively, both of which are statistically significant ($P <0.01$).

Previously published trends for individual populations, where counting fences exist, can be found in Figure 21. Supplementary abundance data (for Biscay Bay River) are provided in Appendix 1.

The Conne River has exhibited the most substantial decline, strongly influencing the total abundance for DU 4.

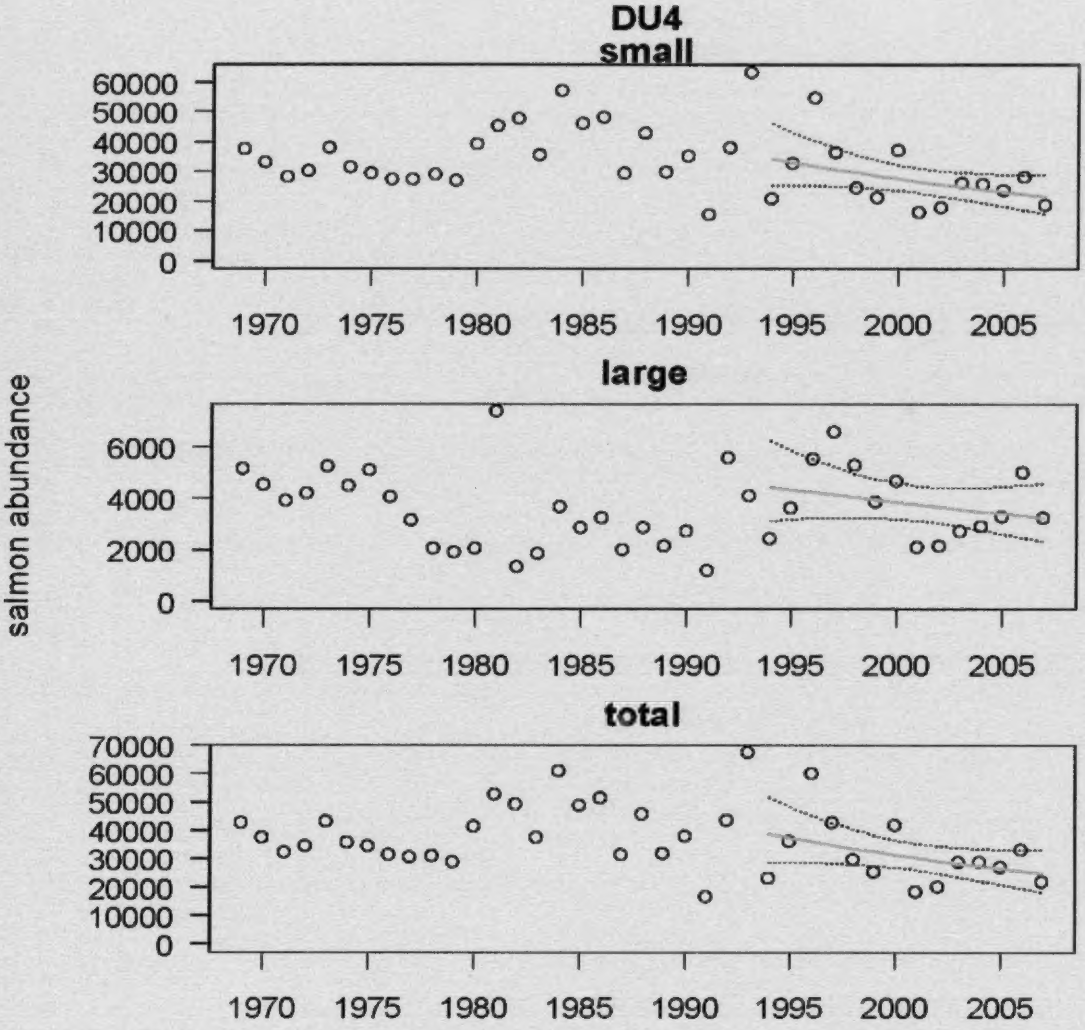


Figure 20. Atlantic Salmon escapement (small: top panel; large: middle panel; total: bottom panel) for DU 4 (1969-2007). Superimposed is the general linear model (+/- 2SE prediction intervals) used to determine trends in abundance over the past 3 generations.

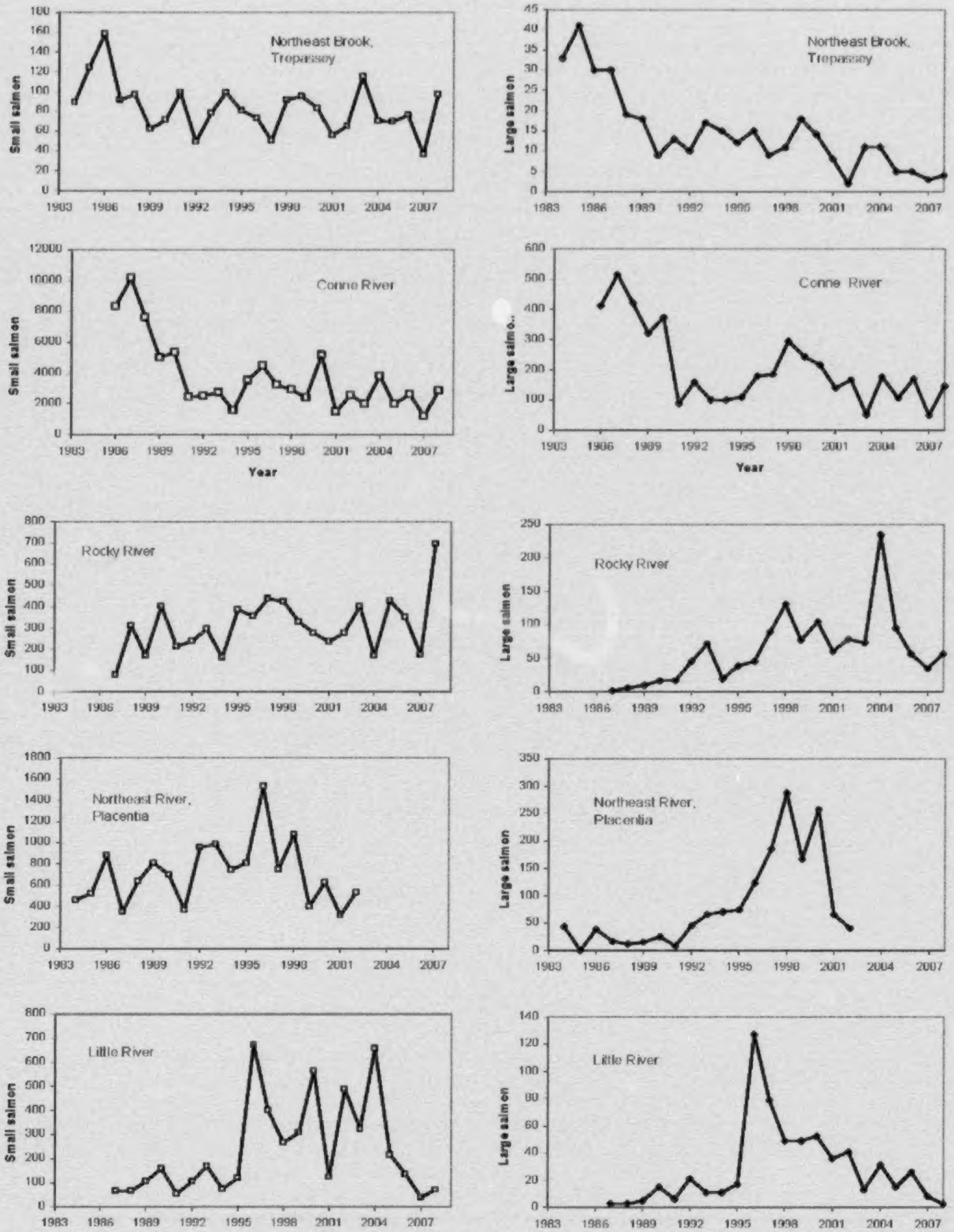


Figure 21. River-specific trend data from the five active counting facilities (Northeast Trepassey, Conne, Rocky, Northeast Placentia, and Little Rivers) in DU 4. Data for small (left panels) and large salmon (right panels) are presented separately for each river (taken from Reddin and Veinott 2010).

Designatable Unit 5 – Southwest Newfoundland

The data available for DU 5 consisted of angler (1969 – 2007) and commercial (1969 – 1992) catch data, and counts from two counting fences. Five of the DU 5 rivers are also assessed with annual swim-through surveys. Angler catch data was based on a mean estimate of 25,899 rod days per year with a range of 18,544-38,487. Angling effort has increased significantly (P= 0.004); by nearly 240% over the data set. Estimates of abundance for the entire DU were calculated based on angler catch and effort data, adjusted using catch rate data from rivers with counting fences (Reddin and Veinott 2010). Furthermore, where angling data were unavailable, abundance was scaled according to available habitat. While these fishery-dependent data are corrected with fishery-independent data, estimates should be considered with the same caveats described above.

DU 5 has an estimated 40 rivers with salmon populations. There have been no known extirpations in this DU. The most recent estimate of adult abundance for DU 5 is 44,566 (32,143-56,988) from 2007, with 37,679 (27,828-47,531) being small salmon, and 6,886 (4,315-9,457) being large salmon. The lowest abundance during the last three generations was in 1991 with 15,488 salmon while the highest abundance was 68,441 in 2006. There was a significant increase in the abundance of small, large and total salmon (all P values < 0.001). The abundance of small salmon (based on the curve fit in Figure 22) is 132.1% greater than three generations previous. Over the same time period, the abundance of large salmon increased by 143.7, while total salmon abundance is 133.6% greater (Figure 22). Despite increasing trends and four of five monitored rivers meeting conservation requirements, population abundance in these rivers is considered low (DFO 2008). Trends for individual populations where counting fences exist can be found in Reddin and Veinott (2010). The Humber River is the largest population in this DU with abundance estimates ranging from 6,125 to 32,118 salmon. Abundance in populations south of the Humber, in the Bay St. George region, ranged from 235 to 3,684 salmon, with Harry's River having the highest abundance estimates. Data for snorkel-surveyed rivers (Harry's, Robinsons, Crabbes, Fischells and M. Barachois) are provided in Figure 23. Supplementary abundance data (for Highlands, Flat Bay, Humber and Grand Bank rivers) are provided in Appendix 1.

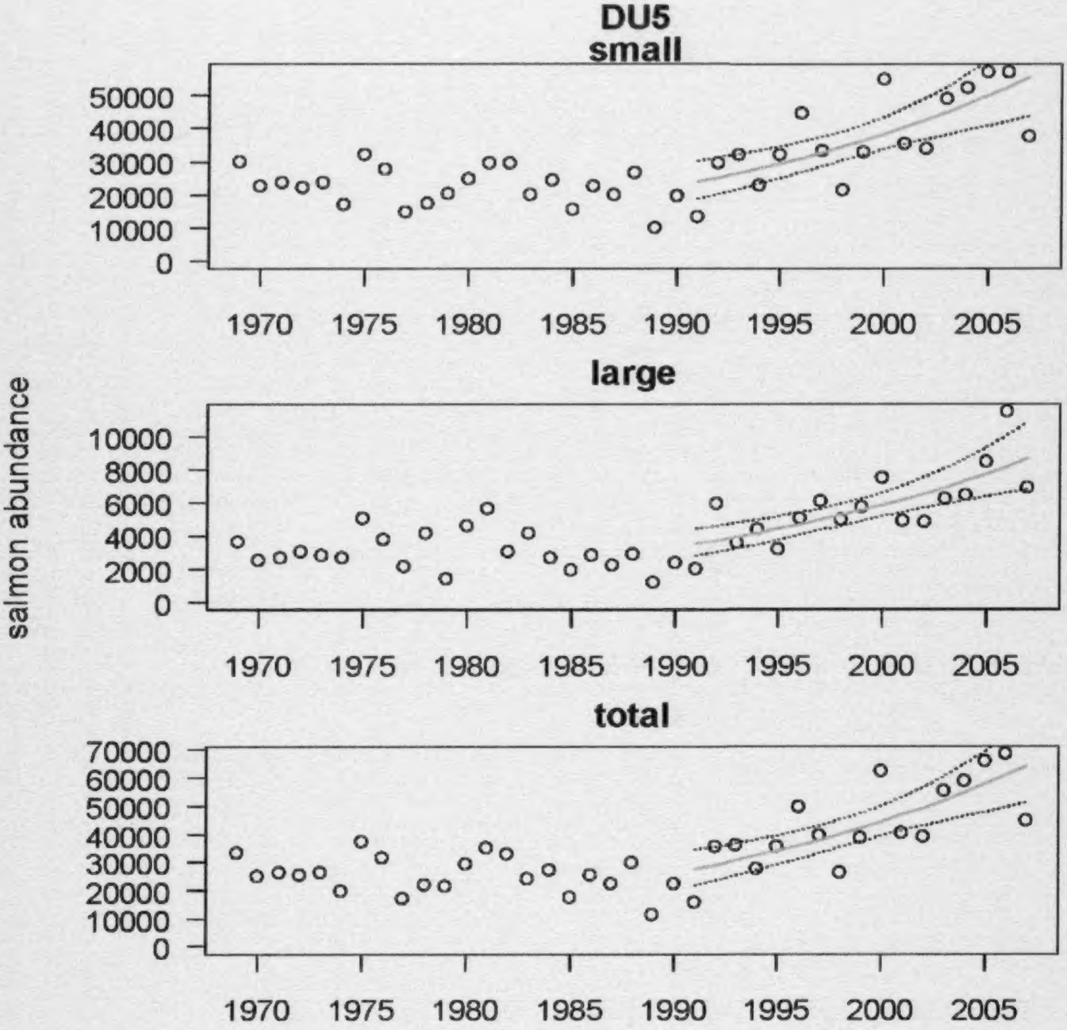


Figure 22. Atlantic Salmon escapement (small: top panel; large: middle panel; total: bottom panel) for DU 5 (1969-2007). Superimposed is the general linear model (+/- 2SE prediction intervals) used to determine trends in abundance over the past 3 generations.

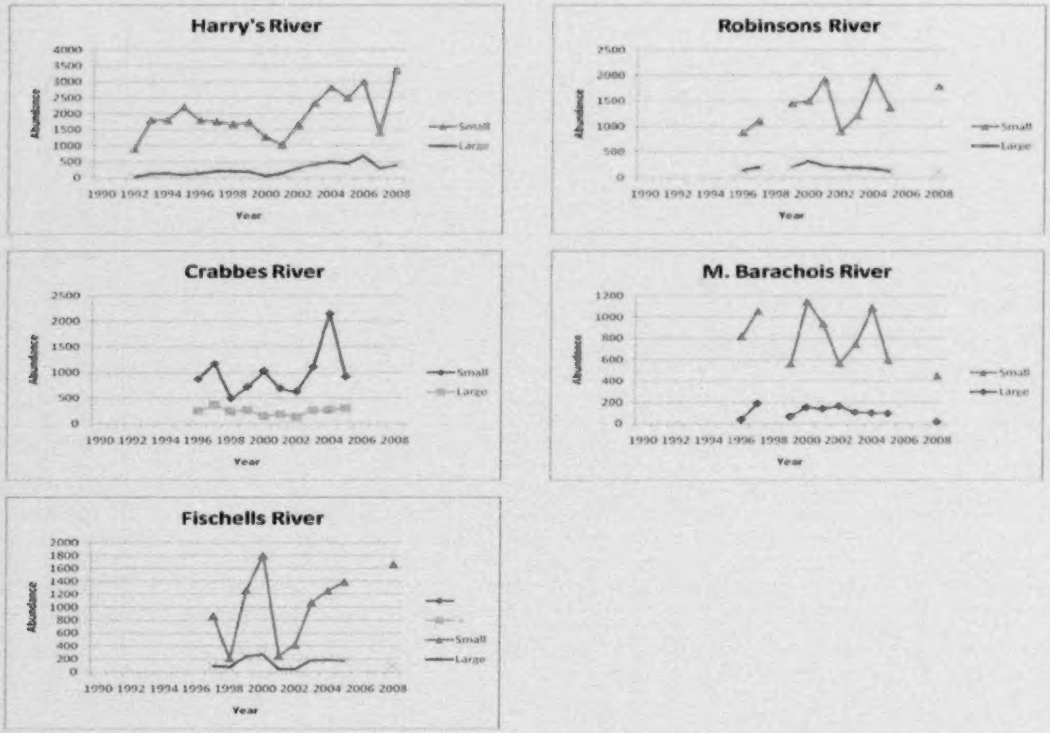


Figure 23. Abundance estimates for Atlantic Salmon in snorkel-surveyed rivers of DU 5 (taken from Reddin and Veinott 2010).

Designatable Unit 6 – Northwest Newfoundland

The data available for DU 6 consisted of angler (1969 – 2007) and commercial (1969 – 1992) catch data, and counts from three counting fences; although data are not available from the three fences in all years (Reddin and Veinott 2010). Angler catch data was based on a mean estimate of 15,517 rod days per year with a range of 10,386-19,695. Angling effort has decreased significantly (P= 0.004) to 82% of mid-90s values. The Torrent River has had a substantial amount of habitat made available as part of an enhancement project. Significant increases in abundance of this population may influence overall trends in the DU. Estimates of abundance for the entire DU were calculated based on angler catch and effort data, adjusted using catch rate data from rivers with counting fences (Reddin and Veinott 2010). Estimates should be considered with the same caveats described above.

There are 34 salmon rivers in DU 6, of which none have been extirpated. The most recent estimates of adult abundance for DU 6 is 31,179 (20,061-42,296) from 2007, with 26,603 (17,786-35,420-9,457) being small salmon, and 4,576 (2,275-6,876) being large salmon (Figure 24). Abundance estimates during the last three generations range from 19,369 salmon in 1994 to 51,570 salmon in 1996. There were no significant trends in the abundance of small, large or total salmon (P = 0.838, 0.125, and 0.999 respectively). The abundance of small salmon (based on the curve fit in Figure 24) has decreased by 4.2% over the last three generations. The abundance of large salmon is 41.7% greater over the same time period, and the trend line for the abundance of total salmon has a slope of zero over this time period (Figure 24). Abundance estimates were available from two monitored rivers in this DU in 2008 (Torrent River and Western Arm Brook) and both were above the conservation requirement (DFO 2008). Supplementary abundance data (for Lomond, Torrent rivers and Western Arm Brook) are provided in Appendix 1.

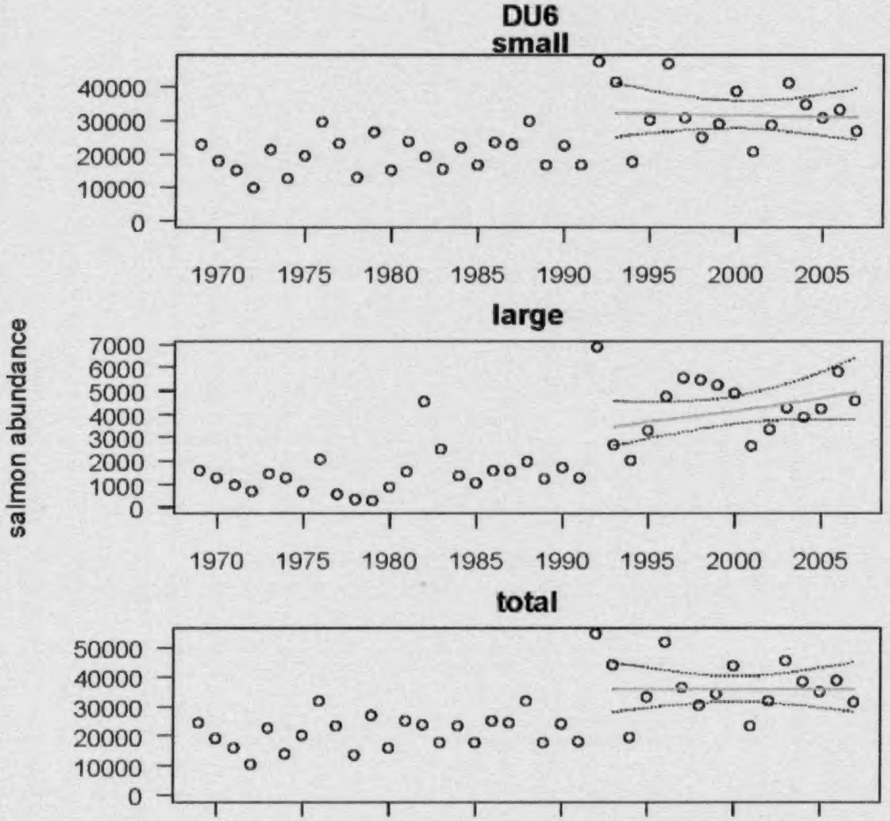


Figure 24. Atlantic Salmon escapement (small: top panel; large: middle panel; total: bottom panel) for DU 6 from 1969 to 2007. Superimposed is the fit from the general linear model (+/- 2SE prediction intervals) used to determine trends in abundance over the past 3 generations.

Designatable Unit 7 – Quebec Eastern North Shore

Data from Quebec are derived from various methods, including direct counts (fence and snorkel surveys), extrapolations from index rivers (based on available habitat) and angler data (MRNF 2009, MRNF unpublished data). The Ministère des Ressources naturelles et de la Faune in Quebec assigns a classification to the data for each river C1-C6 (C1 being the highest quality data) that rates the quality of the abundance data. Many of these classifications can include multiple data types (e.g., counting fences and snorkel swim-throughs). The general data classifications for the rivers in each DU are presented for DUs 7-10. DU 7 had four C3 rivers, three C5 rivers and eight C6 rivers.

All 15 salmon rivers of DU 7 were represented in the data set over the time period 1984 – 2008. Mean rod-days per year was 2,402 with a range of 1,892-3,230. Effort has been declining over the time series ($P<0.001$). The most recent estimate of adult abundance for DU 7 is 5,901 salmon in 2008, of which 69% were small salmon (Figure 25). Abundance estimates during the last three generations range from 4,026 salmon in 1997 to 7,785 salmon in 1993. There were no significant trends in small, large and total salmon abundance ($P=0.085$, $P=0.115$; $P=0.297$ respectively). The abundance of small salmon (based on the curve fit in Figure 25) declined by -26.3% during the last three generations; however, this decline was partially offset by a 50.8% increase in the abundance of (more fecund) large salmon, with the total number of salmon down by 13.8% (Figure 25). Supplementary abundance data (for the Musquanousse and Vieux Fort) are provided in Appendix 1.

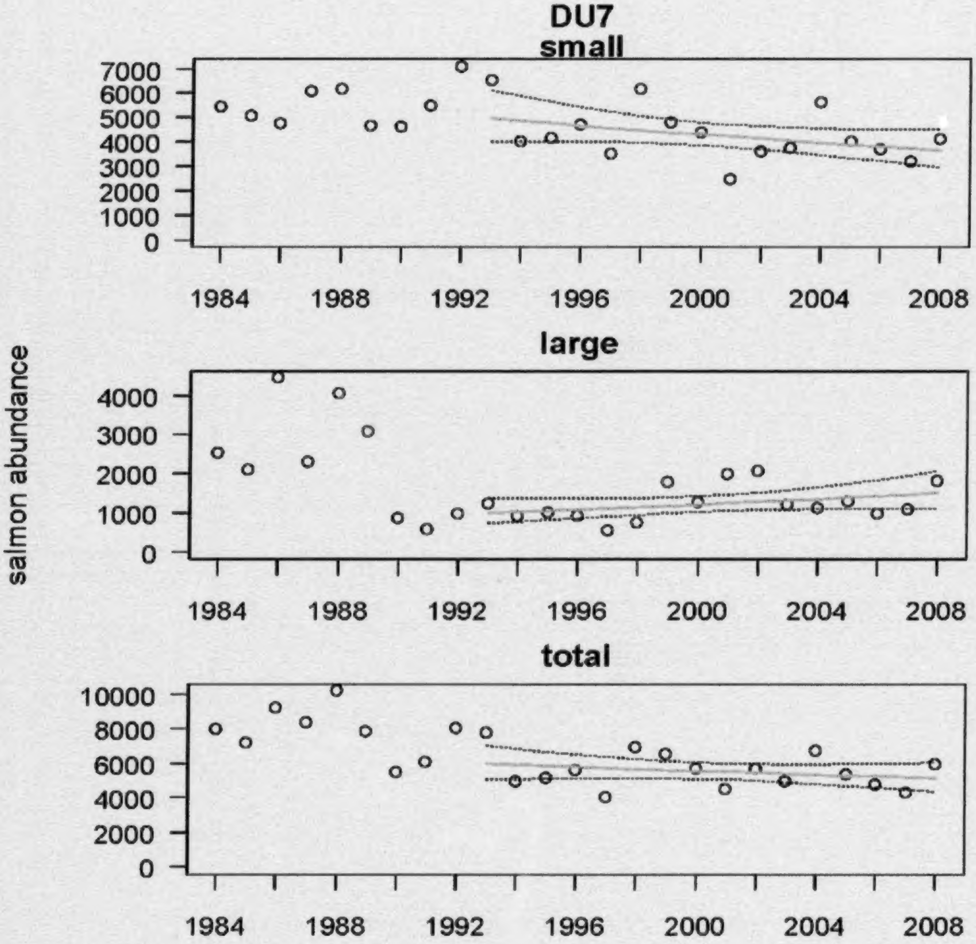


Figure 25. Atlantic Salmon escapement (small: top panel; large: middle panel; total: bottom panel) for DU 7 from 1984-2008. Superimposed is the general linear model (+/- 2SE prediction intervals) used to determine trends in abundance over the past 3 generations.

Designatable Unit 8 – Quebec Western North Shore population

Data from Quebec are derived from various methods, including direct counts (fence and snorkel surveys), extrapolations from index rivers (based on available habitat) and angler data (MRNF 2009, MRNF unpublished data). DU 8 has three C1 rivers, nine C3 rivers, three C4 rivers, seven C5 rivers, and seven C6 rivers (See DU 7 for description of river data classification).

The 29 salmon rivers of DU 8 are represented over the time period 1984 – 2008. The most recent estimate (2008) of adult abundance for DU 8 is 15,135, of which 73% are large salmon. Abundance estimates during the last three generations range from 9,865 salmon in 2002 to 17,341 salmon in 1995. There were significant declines in small and total salmon abundance (P=0.031, P=0.013 respectively). A significant trend was not associated with large salmon abundance (P=0.143). Over the last three generations, the abundance of small salmon (based on the curve fit in Figure 26) declined by 33.9%, while large salmon declined by 20.1% and total salmon by 24.4% (Figure 26).

Data for de la Trinité river, an index river monitored with a fish ladder, is provided in Figure 27. Supplementary abundance data (Laval, Mistassini, Godbout, de la Trinité, aux Rochers, Jupitagon, Mingan, de la Corneille, Piashti, Watshishou, Petite Rivière de la Watshishou, des Escoumins) are provided in Appendix 1. There have been no populations lost from DU 8.

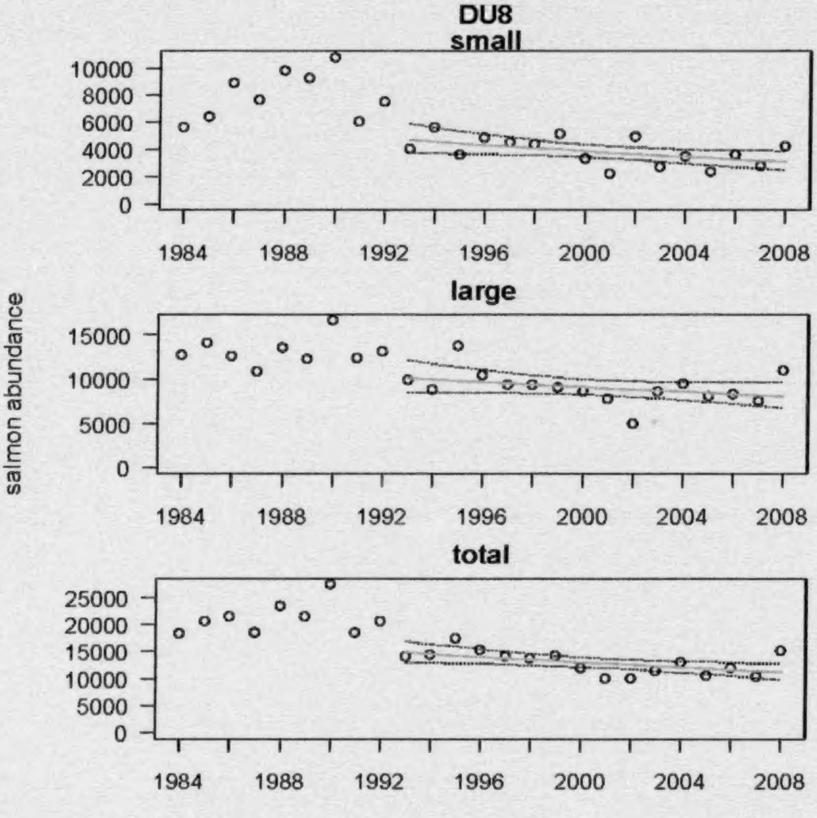


Figure 26. Atlantic Salmon escapement (small: top panel; large: middle panel; total: bottom panel) for DU 8 from 1984-2008. Superimposed is the fit from the general linear model (+/- 2SE prediction intervals) used to determine trends in abundance over the past 3 generations.

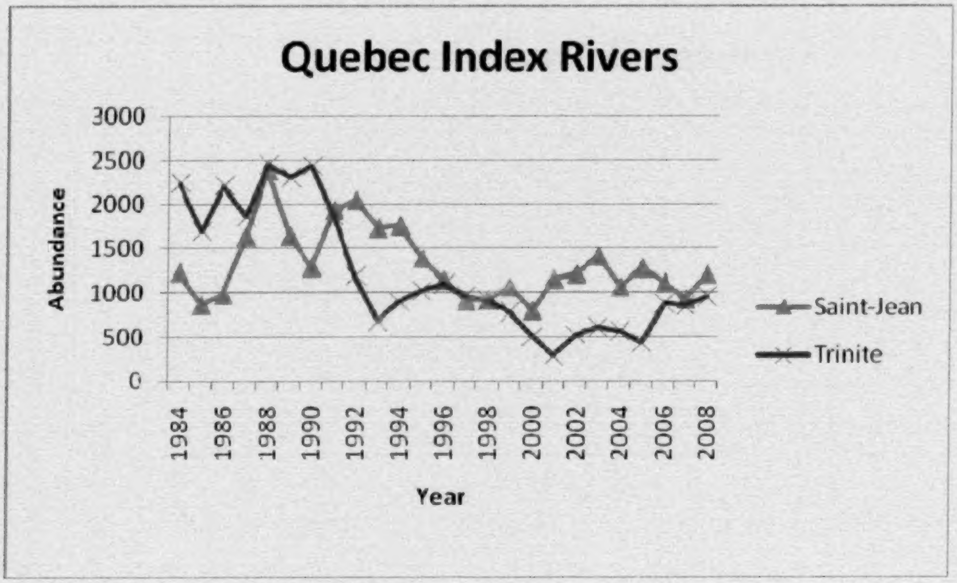


Figure 27. Quebec Index Rivers (Saint-Jean and Trinité). Counting fence data from 1984-2008. Note the Saint-Jean lies within DU 12 while the Trinité is within DU 8.

Designatable Unit 9 – Anticosti Island

Data from Quebec are derived from various methods, including direct counts (fence and snorkel surveys), extrapolations from index rivers (based on available habitat) and angler data (MRNF 2009, MRNF unpublished data). Salmon abundance data is available from 25 rivers on Anticosti Island and 24 of them were classified according to the type of data available. DU 9 has one C1 river, one C3 river, 19 C4 rivers, and three C6 rivers (See DU 7 for description of river data classification).

The most recent estimate (2008) of adult abundance for DU 9 is 2,414 salmon, comprised of 1,362 small and 1,052 large salmon. Abundance estimates during the last three generations range from 1,390 salmon in 2005 to 4,855 salmon in 1996. The declining trend in abundance detected for small salmon (Figure 28) was marginally insignificant ($P = 0.077$), and statistically significant declines in large and total salmon were observed (respective P-values: 0.017 and 0.007). The abundance of total salmon (based on the curve fit in Figure 28) has declined by 31.7% over the last 3 generations. The abundance of both large (48.7%) and small (40.2%) salmon has declined during this period. Supplementary abundance data (á l'Huile, MacDonald, á la Patate, Vaureal, aux Saumons, du Renard, Petite rivière de la Loutre, Bell, Box, Dauphine, Petite rivière de la Chaloupe, Maccan, de la Chaloupe, Ferree, Martin, du Pavillon, aux Plats, Chicotte, Galiote, du Brick, Jupiter, à la Loutre, Bec-scie) are provided in Appendix 1. There have been no populations lost in DU 9.

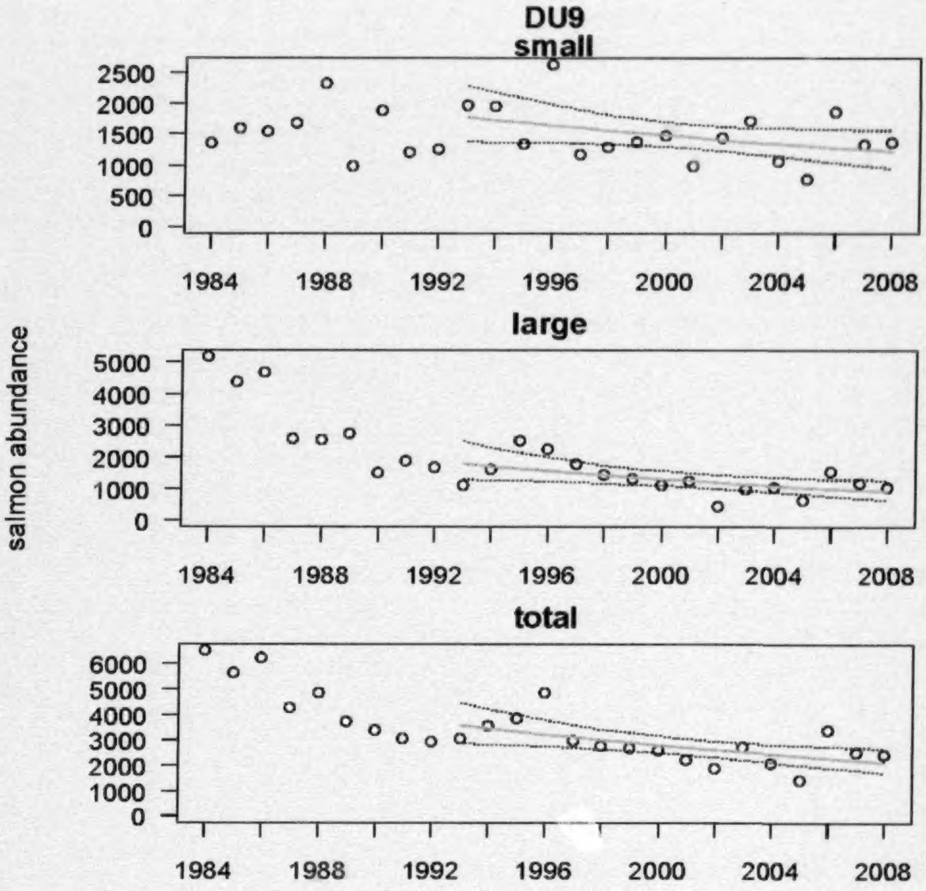


Figure 28. Atlantic Salmon escapement (small: top panel; large: middle panel; total: bottom panel) for DU 9 from 1984-2008. Superimposed is the fit from the general linear model (+/- 2SE prediction intervals) used to determine trends in abundance over the past 3 generations.

Designatable Unit 10 - Inner St. Lawrence

Data from Quebec are derived from various methods, including direct counts (fence and snorkel surveys), extrapolations from index rivers (based on available habitat) and angler data (MRNF 2009, MRNF unpublished data). The nine known salmon rivers of DU 10 are represented in the dataset. DU 10 has six C1 rivers, and three C4 rivers (See DU 7 for description of river data classification).

The most recent estimate (2008) of adult spawner abundance for DU 10 is 4,169 salmon, the highest over the last three generations, consisting of 2,230 small salmon and 1,939 large salmon.The lowest spawner abundance during the last three generations was in 2007 (2,208 salmon). There were no significant trends in abundance for small, large or total salmon (small: P=0.951; large: P=0.429; total: P=0.772; Table 2).

The abundance of large and total salmon (based on the curve fit in Figure 29) has increased by 11.5% and 5.3% respectively since 1997, while small salmon abundance has declined by 1.8% during this time period. Supplementary abundance data (Ouelle, Malbaie, St.-Jean, à Mars, Ste.-Marguerite principale, Ste.-Marguerite NE) are provided in Appendix 1.

Despite relatively stable trends, effective population sizes for salmon in the rivers of DU 10 are relatively low (Dionne *et al.* 2007). Furthermore, many populations in this area have been supplemented by stocking (M. Dionne, Quebec Ministère des Ressources naturelles et de la Faune, pers. comm.). To date, all known salmon rivers contain populations.

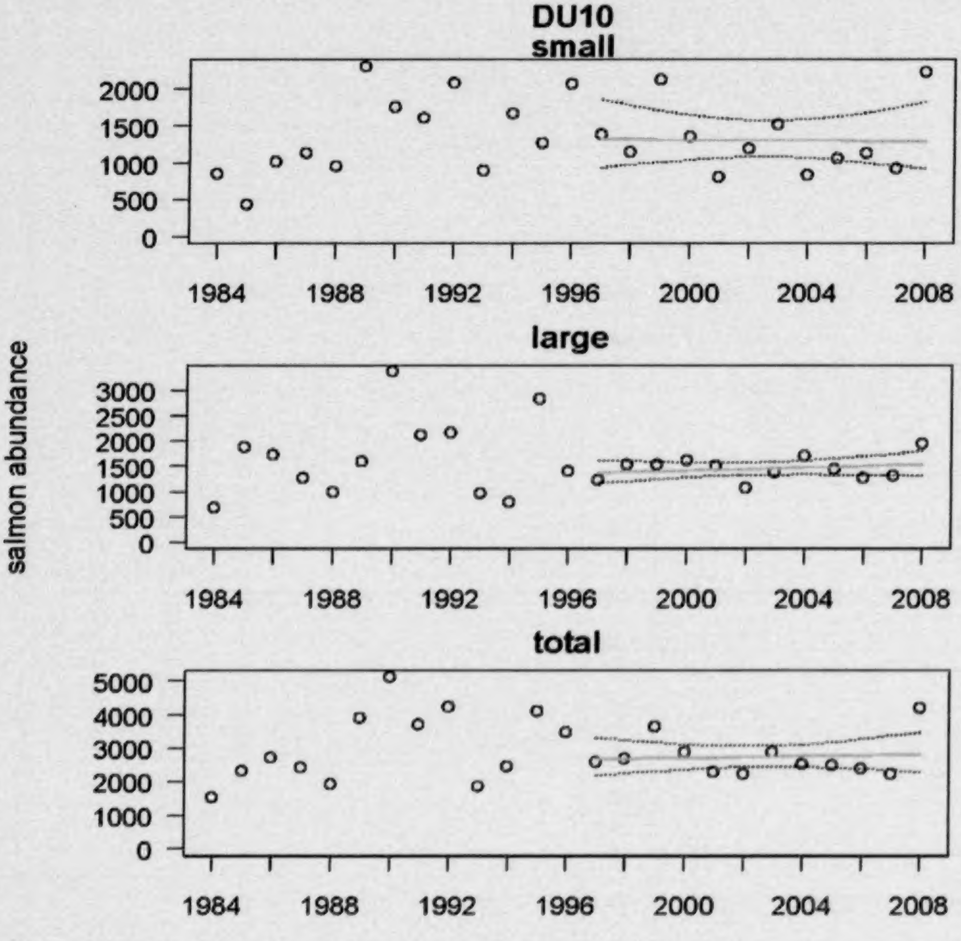


Figure 29. Atlantic Salmon escapement (small: top panel; large: middle panel; total: bottom panel) for DU 10 from 1984-2008. Superimposed is the fit from the general linear model (+/- 2SE prediction intervals) used to determine trends in abundance over the past 3 generations.

Designatable Unit 11 - Lake Ontario

The Lake Ontario DU has been assessed as extirpated[xix] (COSEWIC 2006a). Attempts are ongoing to re-establish populations through stocking. Since no known genetic material remains from the original populations, different strains are being used for restoration efforts. These efforts have not yet succeeded in producing self-sustaining, naturally reproducing populations.

Designatable Unit 12 – Gaspé–Southern Gulf of St. Lawrence

DU 12 has 78 rivers that contain salmon populations distributed across four provincial jurisdictions (Quebec, PEI, Nova Scotia, and New Brunswick). The data available for DU 12 came from a variety of sources as the DU is comprised of several Quebec and Gulf Salmon Fishing Areas. The specific data sources and collection details can be found in (Breau *et al.* 2009, Cairns *et al.* 2009, MRNF 2009, MRNF unpublished data, Cameron *et al.* 2009, Chaput *et al.* 2010, Fournier *and* Cauchon 2009, Secteur Faune Québec 2009, Dionne *et al.* 2010). Broadly, the data consist of angler catch statistics (1970-2008), counts from up to nine counting fences (range 6 - 9), snorkel surveys, and mark-recapture estimates. The primary estimate of abundance for the whole DU is based on the angler-catch data. While these fishery-dependent data are corrected with fishery-independent data, estimates should be considered with the same caveats described above.

The latest estimate (2007) of adult spawner abundance for DU 12 is 103,149 salmon. The lowest abundance during the last three generations was in 1999 with 77,323 salmon, while the highest abundance was 213,329 salmon in 1993. There were no statistically significant trends in the abundance of small, large or total salmon in this DU (P values: 0.119, 0.217 and 0.100 respectively). The abundance of small, large and total salmon (based on the curve fit in Figure 30) has decreased by 34.0%, 18.5% and 27.8% respectively over the last three generations. These values are sensitive to the length of the time series. For example, increasing or decreasing the length of the time series for total salmon changes the decline rate estimates to 46% or 1.5% respectively. The Miramichi River accounts for the majority of salmon in this DU (>50% of the total DU population in the majority of years). The swamping effect of this single large river should be considered when examining these data. In general, juvenile distribution and densities are good and most rivers are known or are suspected of meeting conservation requirements (Breau *et al.* 2009, Cameron *et al.* 2009, Chaput *et al.* 2010). Southern areas of SFA 16 and PEI are exceptions, as distribution of juveniles is sparse and densities are low (Cairns *et al.* 2009, Chaput *et al.* 2010). Adult salmon abundance in the latter areas is also considered to be below conservation levels (Cairns *et al.* 2009, Chaput *et al.* 2010). Furthermore some small rivers of the Northumberland Strait also appear to be in decline (Gibson *et al.* 2006). PEI in particular is experiencing significant habitat degradation, related to land-use issues and its indigenous stocks have likely been largely replaced by stocked fish in at least some rivers (D. Cairns, Dept. of Fisheries and Oceans, pers. comm.). Abundance data from counting fence facilities and/or dominant rivers of DU 12 are provided (Figures 31-35). Supplementary abundance data (Matapedia, Cascapedia, Petite rivière Cascapedia, Bonaventure, Petite rivière Port Daniel, Port Daniel du Milieu, Port Daniel Nord, du Grand Pabo Ouest, du Grand Pabo, du Petit Pabo, Grande Rivière, St.-Jean, York, Dartmouth, Madeleine, Ste.-Anne, Cap Chat, Matane, Mitis, Restigouche, Nepisiguit, Tabusintac, Bouctouche, Morell, Philip, East Pictou, Sutherlands, West Antigonish) are provided in Appendix 1.

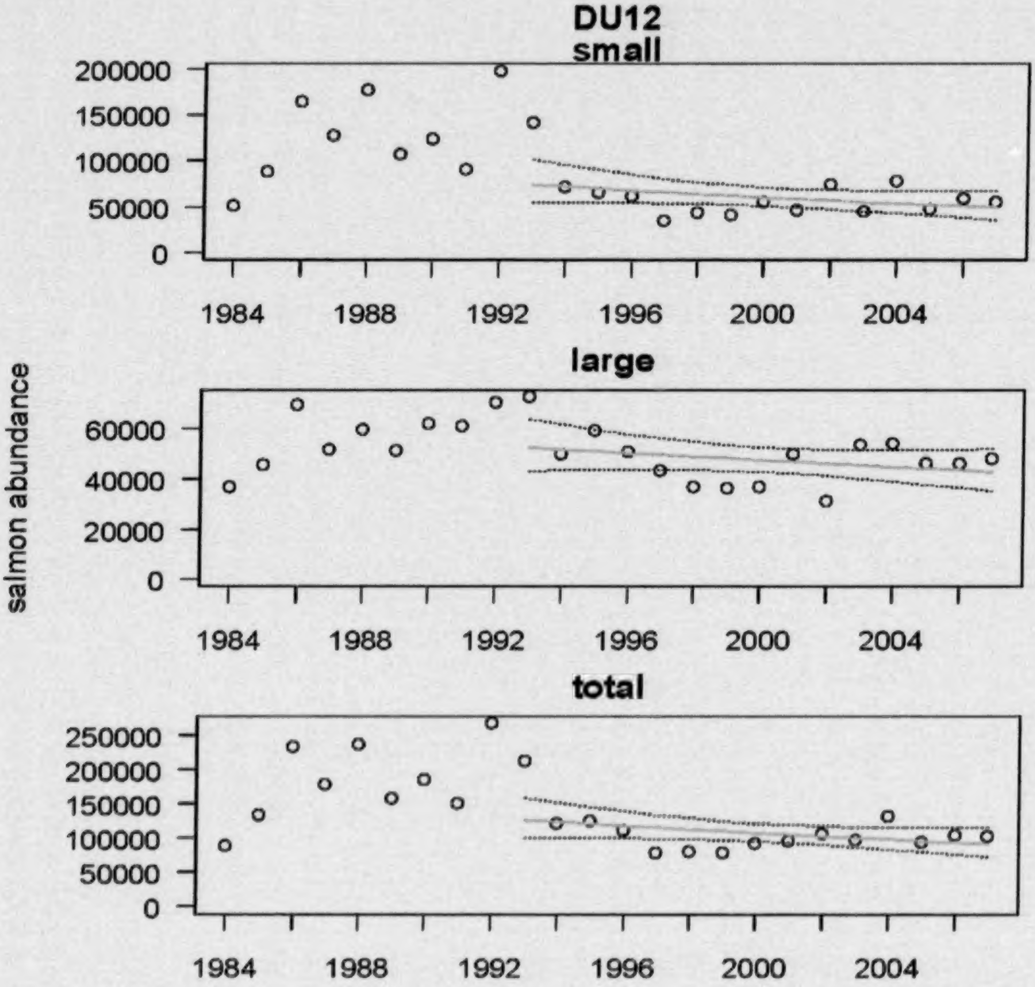
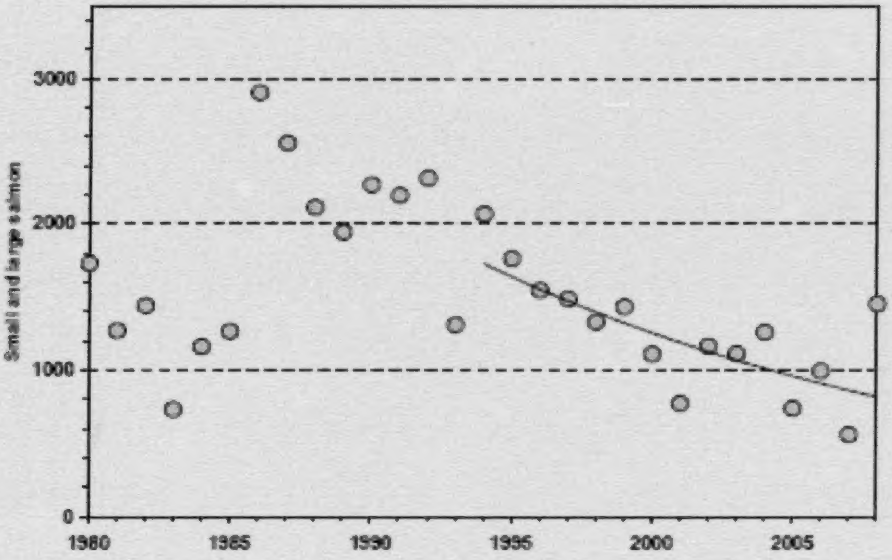


Figure 30. Atlantic Salmon returns (small: top panel; large: middle panel; total: bottom panel) for DU 12 over the past 3 generations. Superimposed is the general linear model (+/- 2SE prediction intervals) used to determine trends in abundance.



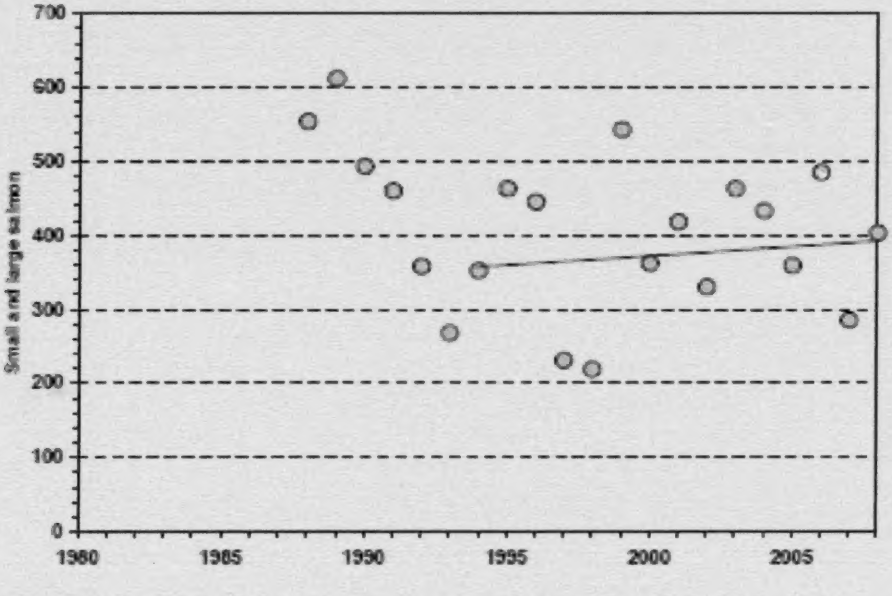


Figure 31. Counts of all adult salmon at the Northwest Upsalquitch Barrier (upper) and Causapscal Barrier (bottom), Restigouche River (taken from Cameron *et al.* 2009).

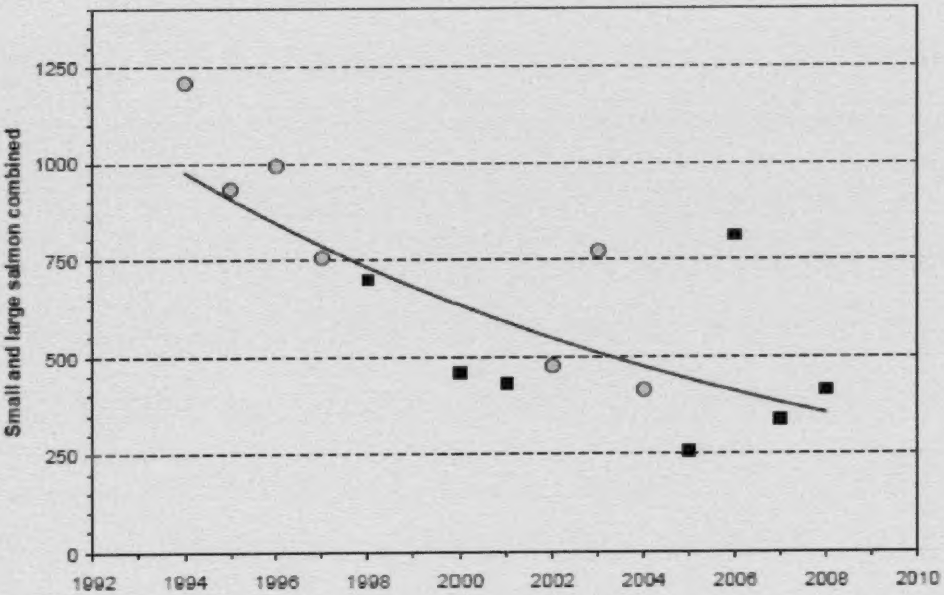


Figure 32. Counts of salmon at the Jacquet River barrier. Square black symbols show years with incomplete counts due to fence washouts or early removal due to inclement weather (taken from Cameron *et al.* 2009).

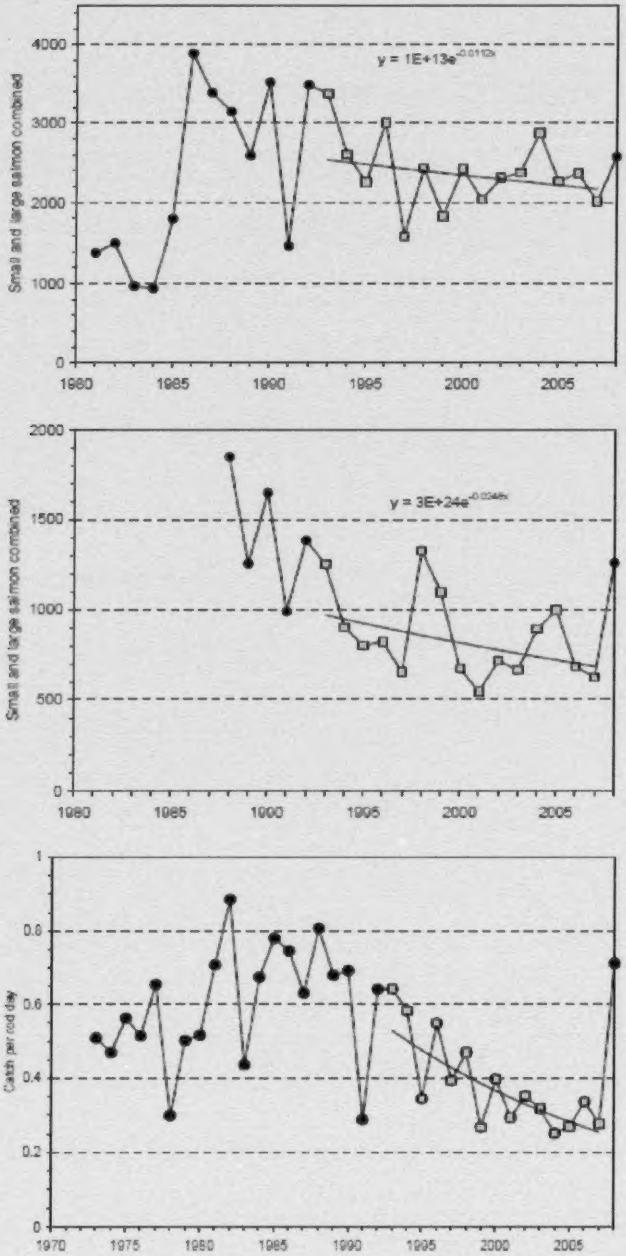


Figure 33. Counts of salmon (size groups combined) at the two headwater barriers in the Southwest Miramichi (upper panel), at the single headwater barrier in the Northwest Miramichi (middle panel) and catch per rod day from the crown reserve angling waters of the Northwest Miramichi (lower panel) (taken from Chaput *et al.* 2010).

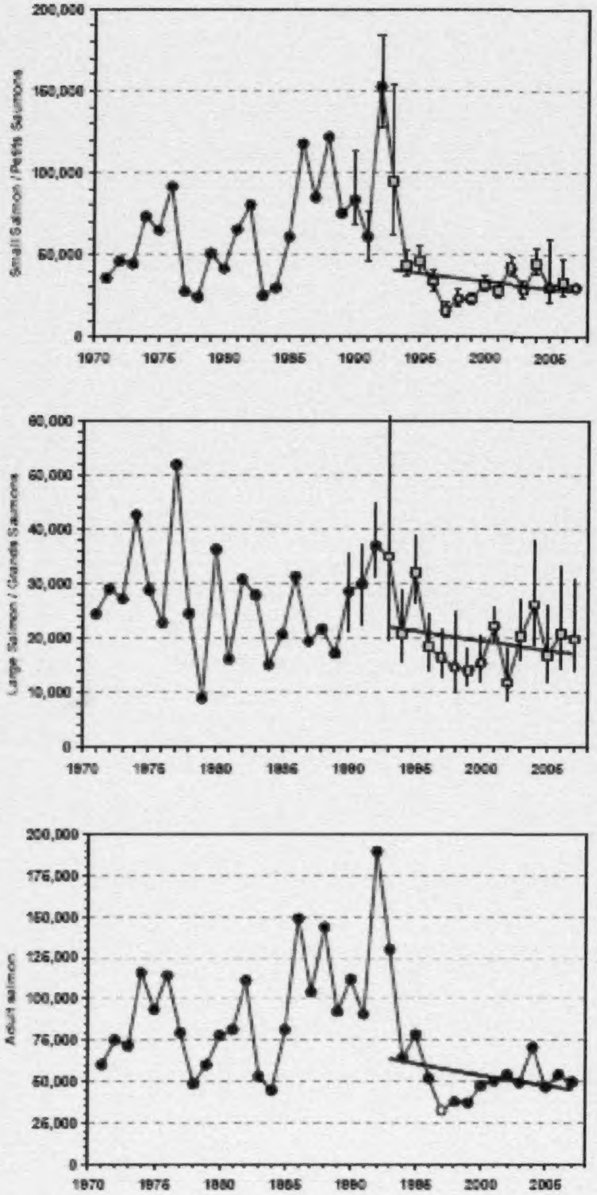


Figure 34. Estimates of returns of small salmon (upper), large salmon (middle) and size groups combined (lower) to the Miramichi River, 1971 to 2007. Trend line is an exponential function for the most recent 15 years (1993 to 2007) (taken from Chaput *et al.* 2010).

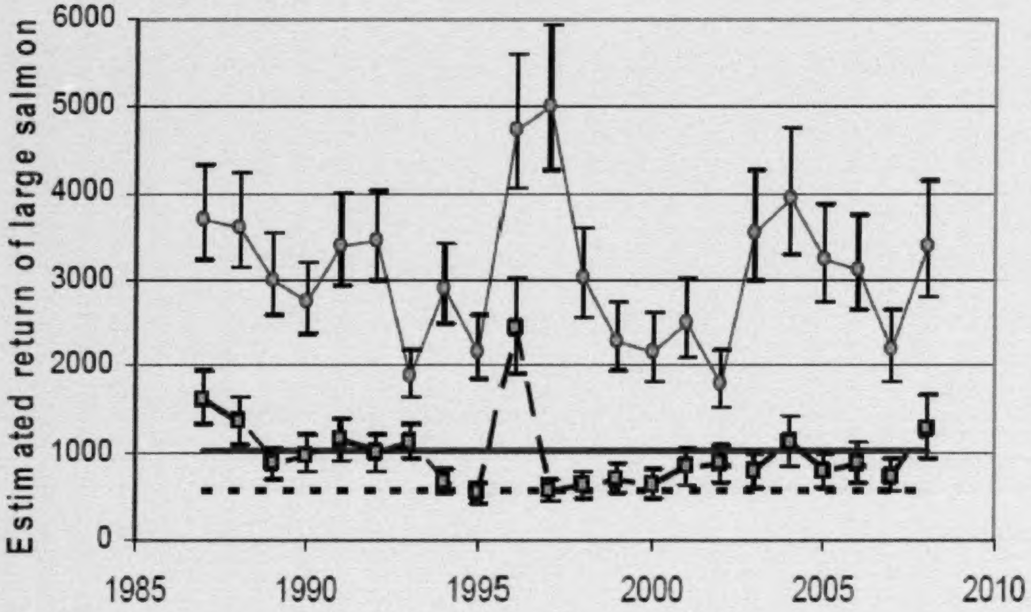


Figure 35. Estimated returns of large (upper series with error bars) and small salmon (lower series with error bars) to the Margaree River, 1987 to 2008. The conservation requirement for large salmon is depicted with a solid line and for small salmon with a dashed line (taken from Breau *et al.* 2009).

Designatable Unit 13 – Eastern Cape Breton

The data available for DU 13 came from a variety of sources including angler catch statistics (1970-2008), fishway counts (1 river), snorkel surveys on four rivers 1994-2008 (except Clyburn 1987-2008) and mark-recapture estimates. Where angler data has been used, its utility as an index has been validated using fishery-independent methods. Data reflect both returns and escapement – depending on the data source. There was no total estimate of abundance available for this DU, but low angler effort on other rivers suggests much of the salmon abundance in this DU is within assessed rivers (Gibson and Bowlby 2009). The spawner abundance data presented here are a sum for rivers with estimates (based on the data provided in Gibson and Bowlby 2009). Since Grand River data was not provided in terms of small and large salmon, data from this river are included only for total salmon. As such the results provided for total salmon do not equal the sum of small and large individuals.

There are 30 rivers in DU 13 with reported recreational catch. The most recent (2008) estimate of adult abundance for DU 13 is 1,150 salmon, of which 407 were small, and 743 were large. During the last three generations, total abundance in the five assessed rivers has ranged from 513 salmon in 2002, to 1,825 salmon in 1996. There were no significant trends in the abundance of small, large or total salmon (P = 0.789, 0.542, and 0.202 respectively) when the abundance time series for this DU are analyzed in aggregate. The abundance of small salmon (based on the curve fit in Figure 36) has declined by 7.9% since 1993, whereas the abundance of large salmon is 14.5% below 1993 levels. The abundance of salmon for both size categories combined has decreased by 28.9% during this time period (Figure 36). Despite the lack of a statistically significant declining trend over three generations, four of five DU 13 rivers were below conservation requirements in 2008 and two had "marked" declines (Gibson and Bowlby 2009). Furthermore, a declining trend can be detected for small (39.6% over four generations; $P = 0.058$), large (67.2%; $P < 0.001$) and total (69.1%; $P < 0.001$) salmon when the data series is extended by five years (four generations). The difference in the trends in total abundance from the large and small abundance series reflects the large decline in abundance in the Grand River (Figure 37), which was not included in the small and large abundance series. Data for individual river systems are plotted in Figure 37. Juvenile abundance levels in the region are not high in comparison to DU 12 rivers, although juveniles remain widespread (Gibson and Bowlby 2009). To date, there have been no known extirpations in this DU.

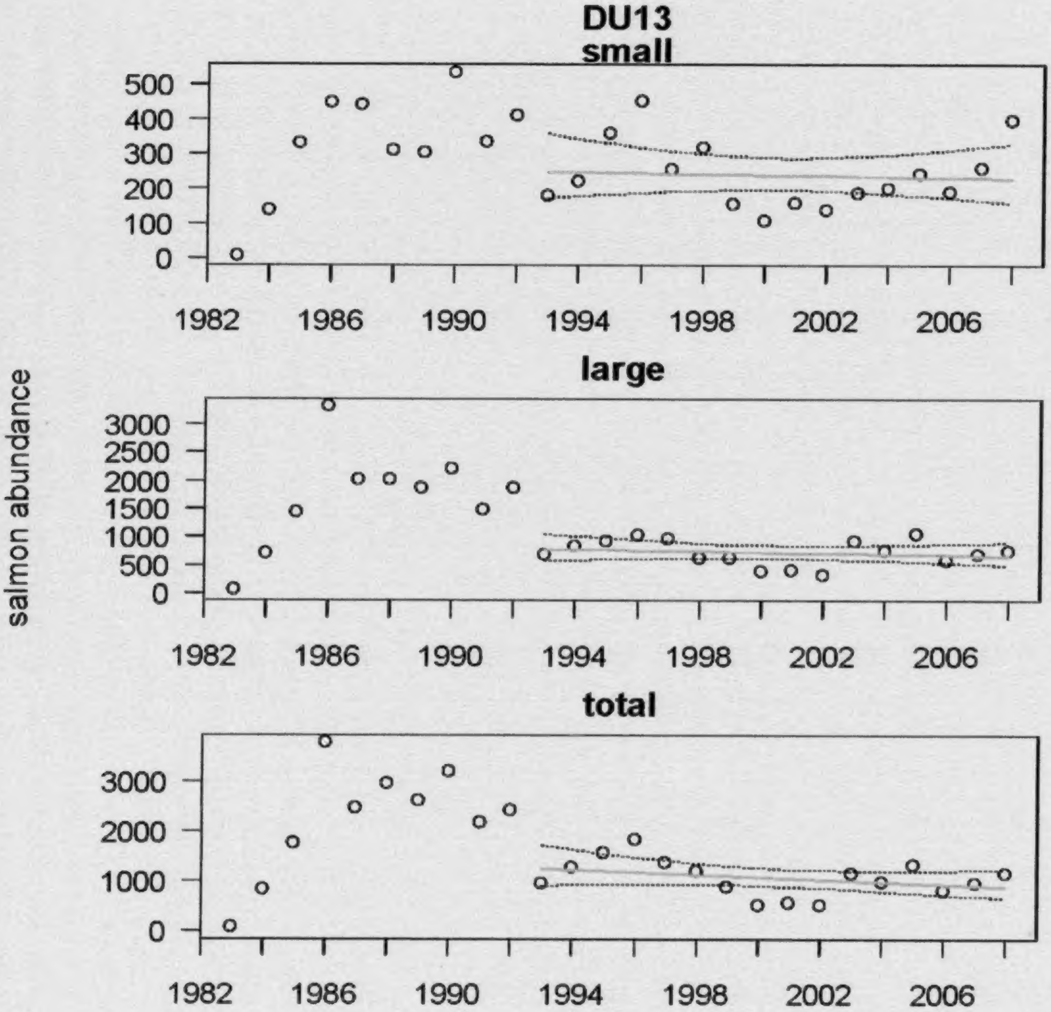


Figure 36. Atlantic Salmon escapement (small: top panel; large: middle panel; total: bottom panel) for DU 13 over the past 3 generations. Superimposed is the fit from a general linear model (+/- 2SE prediction intervals) used to determine trends in abundance. Note contributions from the Grand River are not included in small and large salmon plots due to data limitations.

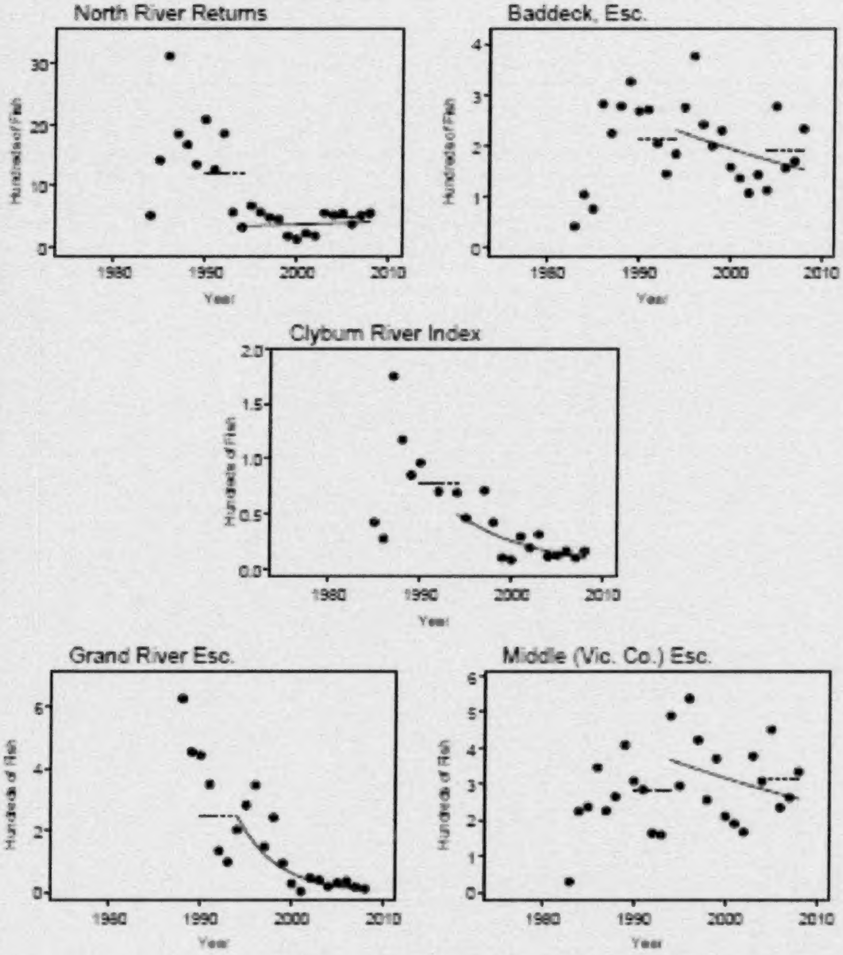


Figure 37. Adult Atlantic Salmon abundance time series (size categories combined) for five eastern Cape Breton rivers. The solid line is the estimated abundance from a log-linear model fit to data for the last three generations. The dashed line shows the 5-year mean abundance for 2 time periods separated by 15 years. The points are the observed data (taken from Gibson and Bowlby 2009).

Designatable Unit 14 – Nova Scotia Southern Upland

The data available for DU 14 come from a variety of sources including angler catch statistics (1970-2008), fishway counts (3 rivers), and mark-recapture estimates (1 river). The trend data used for this section rely entirely on fishery-independent data: the sum of the spawner escapement counts on the two main index rivers was used to assess trends. Abundance estimates from the assessed rivers are not extrapolated to the entire DU using the recreational catch because most rivers are closed to fishing. As such there is no total estimate of abundance available for this DU. The abundance data presented here are a sum for rivers with estimates (based on data in Gibson *et al.* 2009). In recent years, the monitored rivers are biased towards systems with lower acidification impacts. Such rivers, however, are thought to currently contain the majority of salmon in this DU.

Within the previous century, 63 rivers with this DU are known to have contained salmon, although presently, salmon are extirpated from many. The most recent estimate (2008) of adult abundance for the two index rivers is 1,427 salmon, consisting of 1,264 small and 164 large salmon. The lowest abundance during the last 3 generations was 755 salmon in 2007, while the highest abundance was 3,557 salmon in 1996. Abundance of salmon in this DU during the 1980s at times exceeded 10,000. There has been a significant decline in the abundance of small ($P = 0.003$), large ($P = 0.002$) and total salmon ($P < 0.001$) in this DU based on the curve fit in Figure 38. Small salmon abundance declined by 58.6% since 1996 (Figure 38). The abundance of large salmon was down by 74.0%, and total salmon declined by 61.3% during that period. Since recent counts represent systems with relatively low levels of acidification, declines in acidified rivers of DU 14 are expected to be greater (Gibson *et al.* 2009). DU 14 has experienced a substantial decline in the number of individual populations. DFO (2000) predicted that 55% of rivers in this DU are extirpated with an additional 36% at risk of extirpation.

A comparison of juvenile abundance estimated from electrofishing surveys between 2000 and 2008 (Gibson *et al.* 2009) are indicative of ongoing declines and low juvenile abundance (Figure 39). These surveys were similar in terms of total effort and coverage, although marginally more sites were completed in 2008 (143 vs. 128), but one less river was visited (51 rather than 52). Total shocking time was slightly greater in 2008 (143,385 seconds vs. 104,331 seconds), but the total area surveyed was lower (98,019 m^2 vs. 128,841 m^2). Approximately one-quarter as many juvenile salmon were captured in 2008 (977 salmon) than in 2000 (3,733 salmon). In 2000, juvenile Atlantic Salmon were found in 54% of the rivers (28 of 52), but were only found in 39% (20 of 51) of the rivers in 2008.

Under current conditions, maximum lifetime reproductive rates (indicative of the compensatory reserve) of salmon in this DU are very low and abundance will likely continue to decline because the populations have little intrinsic capacity to rebound following events that further lower abundance (Gibson *et al.* 2009). Only a few populations (e.g. the LaHave and St. Mary's rivers) may be viable under current conditions and then only at low population size (Gibson *et al.* 2009). Because of their low reproductive rates, these populations may also be at risk as a result of stochastic processes. Annual salmon counts at the Morgan Falls fishway on the LaHave River, the primary index of abundance in this DU, are provided in Figure 40. Supplementary abundance data (Liscomb, St. Marys, and East River (Sheet Hbr.)) are provided in Appendix 1.

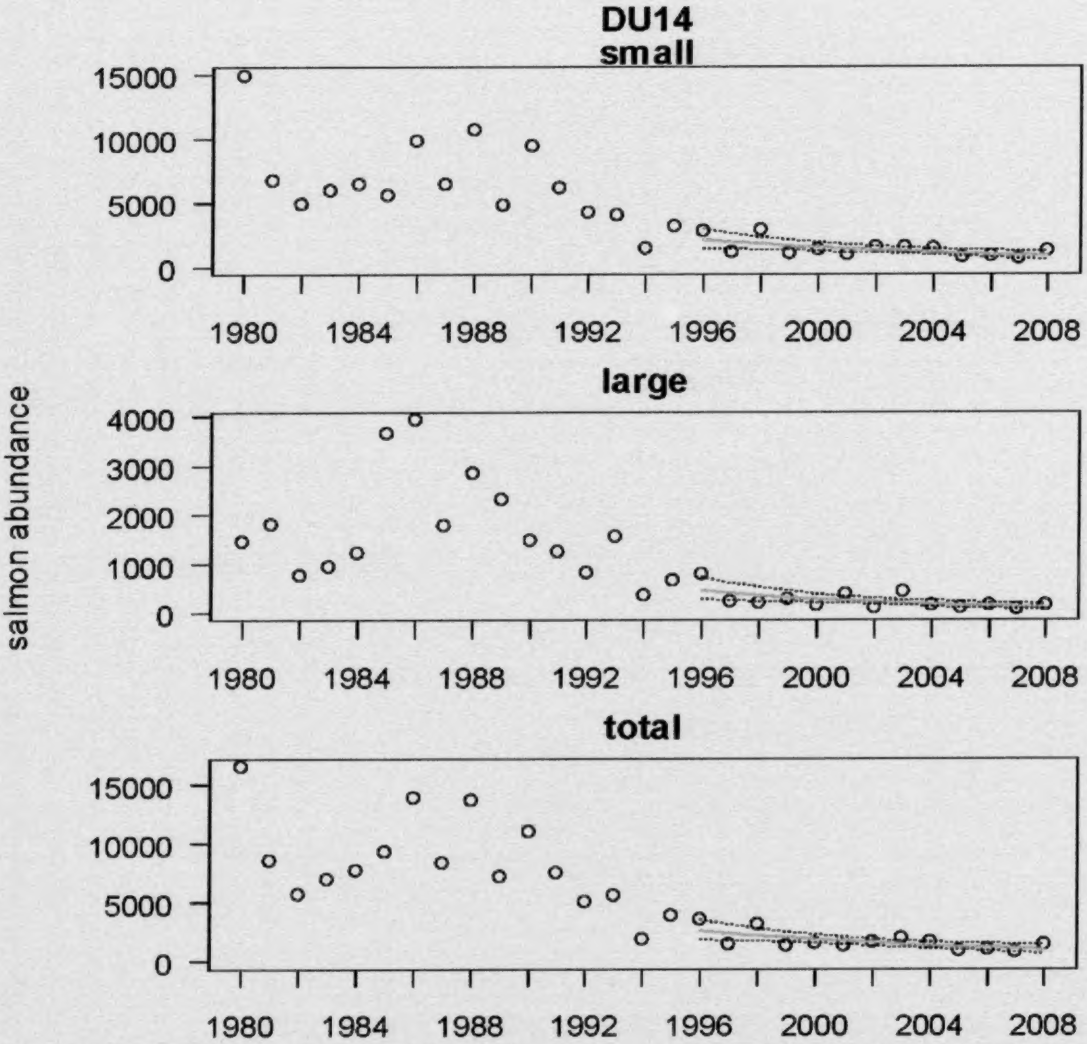


Figure 38. Atlantic Salmon escapement from 1980 to 2008 (small: top panel; large: middle panel; total: bottom panel) for DU 14. Superimposed is the general linear model (+/- 2SE prediction intervals) used to determine trends in abundance over the past 3 generations.

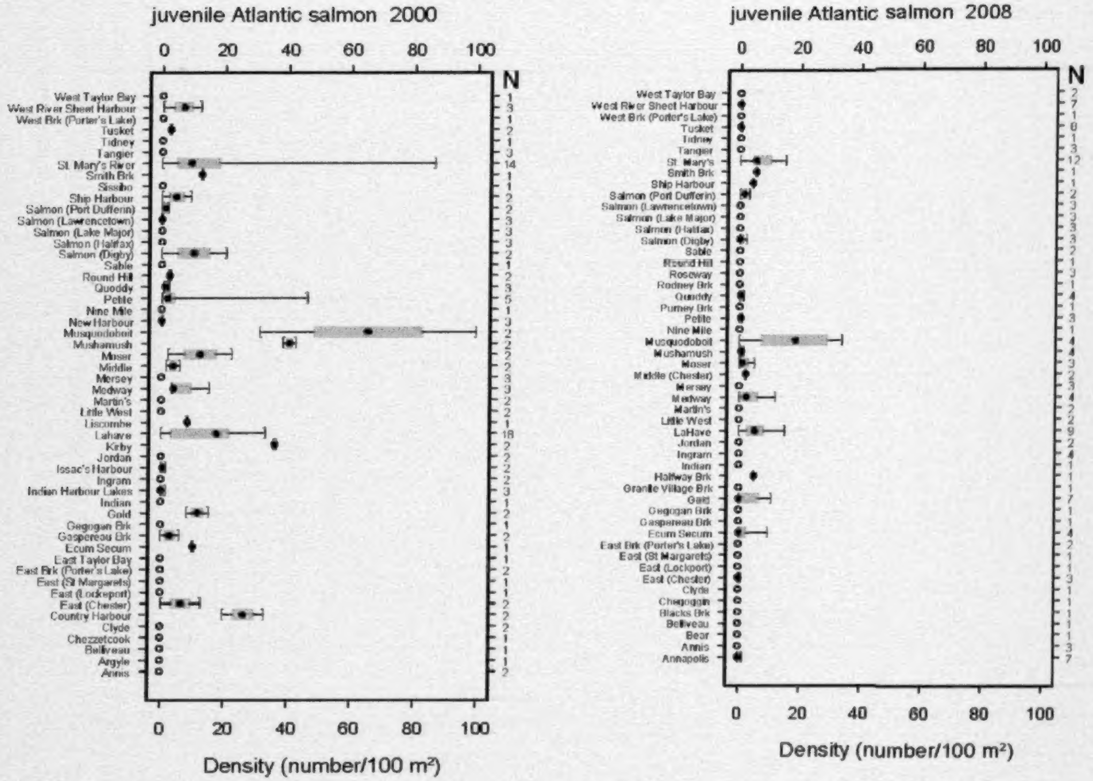


Figure 39. Box plots showing the density of Atlantic Salmon in Southern Upland rivers based on electrofishing during 2000 and 2008. The dot shows the median density and the box shows the inter-quartile spread. Open dots indicate that no salmon were captured in the river. The whiskers are drawn to the minimum and maximum. "N" is the number of sites that were electrofished in each river (adapted from Gibson *et al.* 2009).

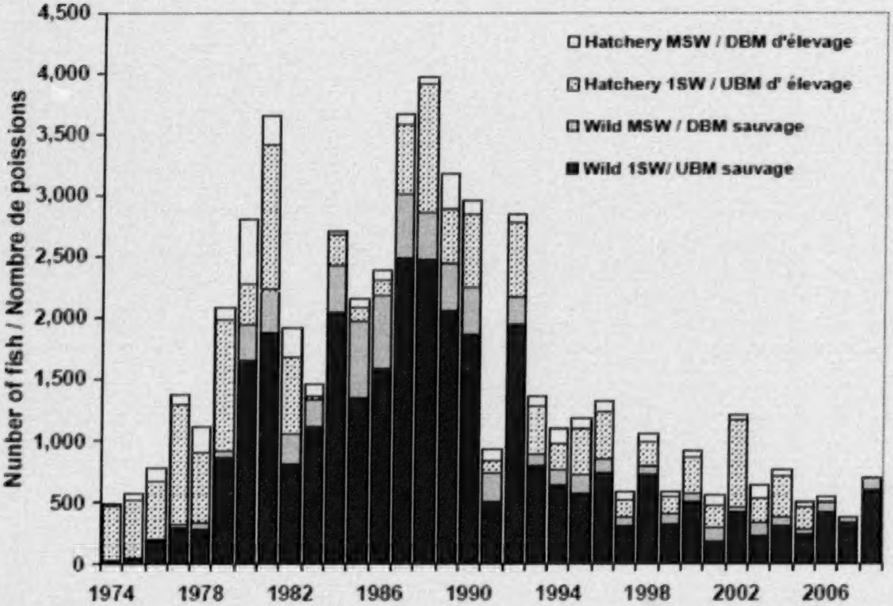


Figure 40. Counts of Atlantic Salmon at Morgans Falls fishway on the LaHave River, NS, from 1974 to 2008, divided into the proportions of wild-origin and hatchery-origin 1SW and MSW adults (taken from Gibson *et al.* 2009).

Designatable Unit 15 – Inner Bay of Fundy

This DU has been designated as Endangered under the SARA. A full status report was prepared in 2006 (COSEWIC 2006b). Current estimates for this DU (2008) suggest the total number of wild fish is likely to be less than 200 individuals.

Designatable Unit 16 – Outer Bay of Fundy

Small and large returns to the Saint John River from 1993 to 2008 were calculated by using the estimated returns to the Nashwaak River (upriver of the counting fence), raised by the amount of habitat available in the Saint John River downstream of Mactaquac Dam plus the total returns destined for above Mactaquac Dam. The returns to the other outer Bay of Fundy rivers were determined by using the total returns to both the Magaguadavic and St. Croix rivers raised by the amount of habitat available to salmon between the Saint John River and the Maine border. Added to the estimated Saint John River returns, these estimates provided the total estimated 1SW and MSW returns to DU 16 (Jones *et al.* 2009).

There are 17 salmon rivers in DU 16. The most recent estimate of adult abundance for DU 16 is 7,584 from 2008. Of these 6,629 were small and 955 were large. The lowest abundance during the last three generations was in 2007 (3,486 salmon). The highest abundance during the last three generations was 20,010 salmon in 1996. There have been significant declines in the abundance of large ($P < 0.001$), small ($P = 0.024$) and total salmon ($P = 0.001$). The abundance of small salmon (based on the curve fit in Figure 41) has declined by 56.5% since 1996 (Figure 41). The abundance of large salmon has declined by 81.6% of 1996 abundance and total salmon are down by 64.3%. Adult escapement is well below conservation requirements for the entire area and juveniles, though well distributed, are also at low densities (Jones *et al.* 2009). While all monitoring facilities show strong declining trends, the St. Croix and the Magaguadavic rivers have been effectively extirpated of wild fish. Data from the Saint John River (Mactaquac), Magaguadavic River and St. Croix River are provided in Figures 42-44.

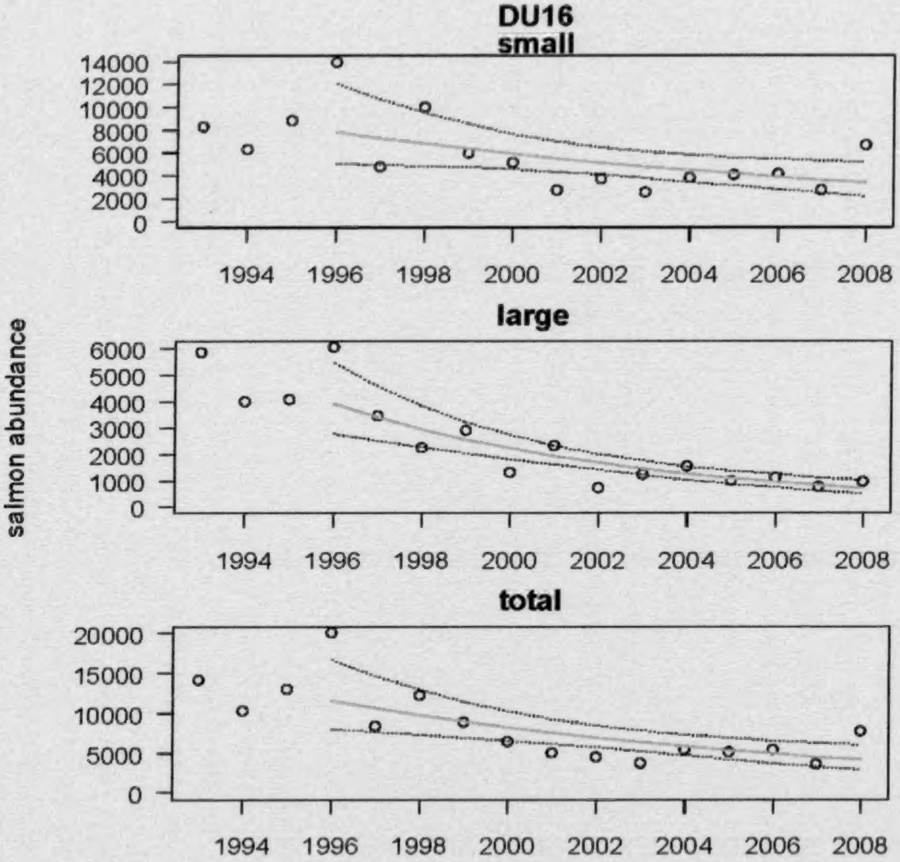


Figure 41. Atlantic Salmon escapement (small: top panel; large: middle panel; total: bottom panel) for DU 16 over the past 3 generations. Superimposed is the general linear model (+/- 2SE prediction intervals) used to determine trends in abundance.

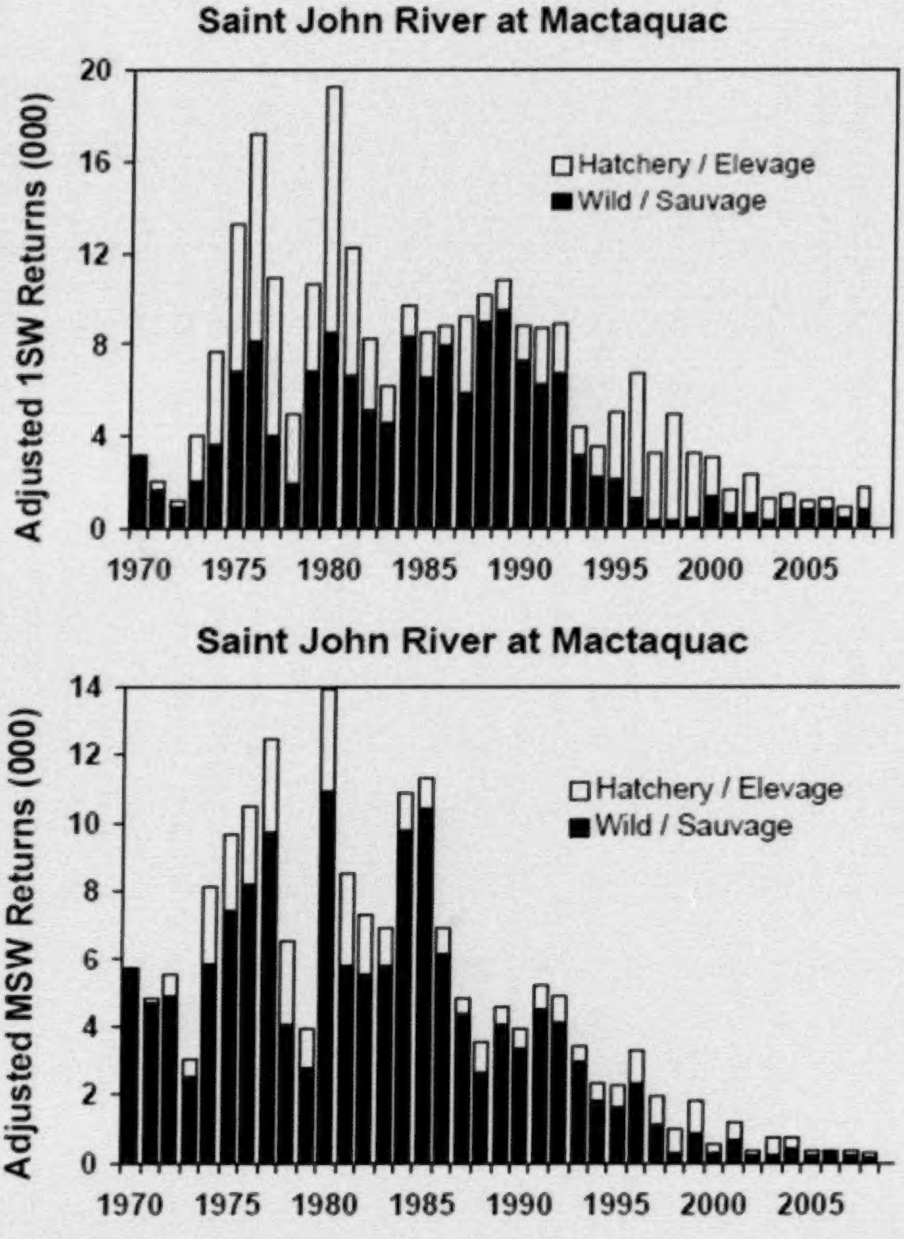


Figure 42. Estimated total adjusted returns of wild and hatchery 1SW and MSW salmon destined for Mactaquac Dam, Saint John River, 1970–2008 (taken from Jones *et al.* 2009).

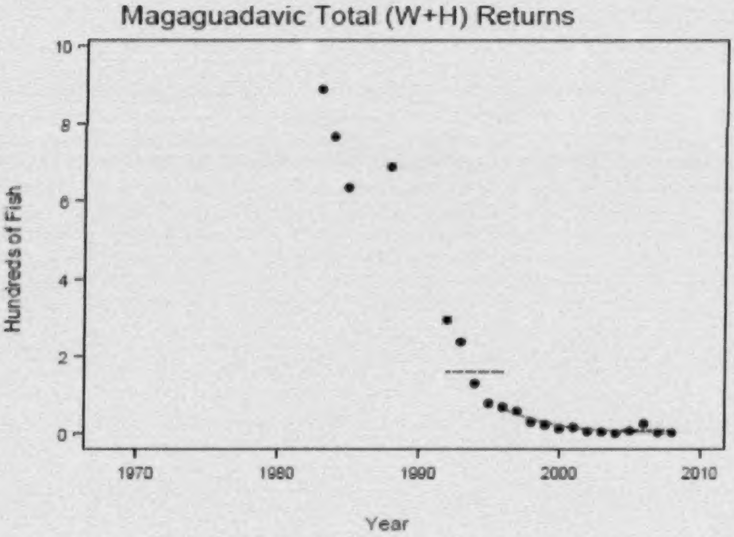


Figure 43. Trends in abundance of adult Atlantic Salmon in the Magaguadavic River during the last 15 years. The solid line is the predicted abundance from a log-linear model fit by least squares. The dashed lines show the 5-year mean abundance for 2 time periods separated by 15 years. The points are the observed data (taken from Jones *et al.* 2009).

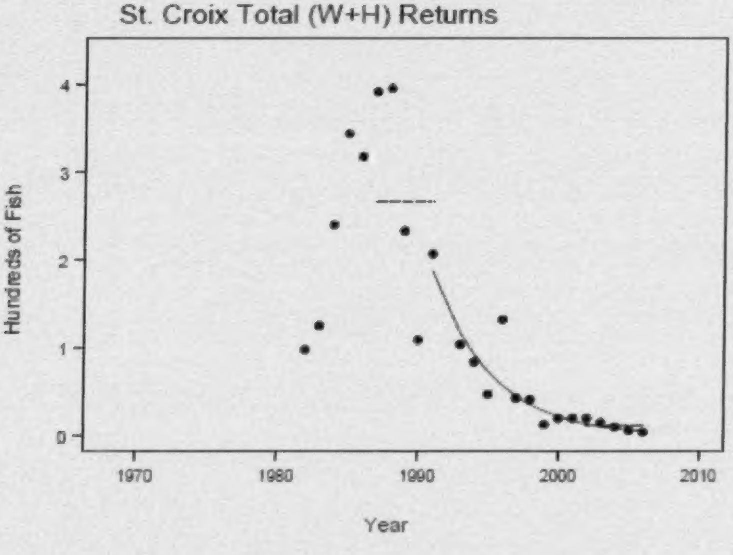


Figure 44. Trends in abundance of adult Atlantic Salmon in the St. Croix River during the last 15 years assessed (1992-2006). The solid line is the predicted abundance from a log-linear model fit by least squares. The dashed lines show the 5-year mean abundance for 2 time periods separated by 15 years. The points are the observed data (taken from Jones *et al.* 2009).

THREATS AND LIMITING FACTORS[xx]

The causes of the widespread decline of Atlantic Salmon (WWF 2001) are not well understood. Several major reviews have attempted to identify and prioritize causes but there is currently no consensus. For example, a group of experts discussed 62 factors potentially threatening the survival of Atlantic Salmon in eastern North America (Cairns 2001). Of the 12 leading factors, five were related to predation, five to life history, one to fisheries, and one to physical/biological environment. Furthermore, two were related to freshwater life stages, nine were related to marine life stages, and one was related to a freshwater cause that manifested itself in the marine stage.

Throughout the range of Atlantic Salmon, poor marine survival has been cited as the primary cause for observed declines (Potter and Crozier 2000, Reddin *et al.* 2000, Amiro 2003, Gibson *et al.* 2004, 2009). Poor marine survival continues to threaten many populations of Atlantic Salmon despite a massive reduction in fishing mortality (COSEWIC 2006b) and adequate freshwater conditions in most, but not all (see DU 14) areas (DFO 2008, Breau *et al.* 2009, Cameron *et al.* 2009, Chaput *et al.* 2010). While the mechanism(s) of marine mortality is uncertain, what is clear is that the recent period of poor sea survival is occurring in parallel with many widespread changes in the North Atlantic ecosystem.

Changes in climate in the early 1990s have resulted in significant physical and biological changes in the North Atlantic including: an enhanced outflow of low-salinity waters from the Arctic through the Labrador Sea, enhancement of stratification on the northwest Atlantic shelf, changes to the seasonality of phytoplankton production, greater abundance of small copepods and a decrease in abundance of older life stages (Greene *et al.* 2008). The relationship between salmon abundance and temperature is reasonably well established (Friedland *et al.* 1993) and therefore changes related to sea surface temperature may be some of the key factors affecting natural mortality (Cairns 2001).

The impacts of climate will not be limited to marine environments. From 1990–2100, mean surface air temperature is projected to increase by 1.4-5.8°C, with more rapid warming in the Northern regions of North America (IPCC 2001). In Atlantic Canada, a 2-6°C increase is expected in the next century with increases in air temperature expected to be greatest in western New Brunswick and Quebec, and lowest in Labrador. The responses of Atlantic Salmon populations across its range in eastern Canada are uncertain, but they are expected to differ across the latitudinal range.

Directed fishing has had catastrophic effects on many fish species (e.g. Pauly *et al.* 2002) including Atlantic Salmon. In Lake Ontario, directed fishing acted in concert with habitat loss to collapse the Atlantic Salmon fishery within 26 years of beginning commercial-scale harvesting (Dunfield 1985). This population was subsequently extirpated by the turn of the 20th century (COSEWIC 2006a).

In eastern Canada, the final closure of major intercept fisheries in 1992 shifted the emphasis of commercial mixed stock salmon fisheries towards Aboriginal and recreational salmon fisheries on river-specific stocks. Fisheries are principally managed on a river-by-river basis and, in the few areas where retention of the dominant egg-bearing size group is allowed, harvests are closely controlled to achieve conservation goals (based on egg-deposition rates). Harvests by all users in Canada in 2008 totalled 132t, the lowest of 47 years of record and only about 5% of peak landings reported 1960 – 1980 (DFO and MRNF 2009). These landings constituted approximately 9.5% of returns to Canadian rivers in 2008.

In 2006, 64% of the reported harvest of Atlantic Salmon occurred in the recreational fisheries. In this fishery, 100% of the effort occurs in fresh water and is therefore river-specific. Impacts of recreational fishing are managed with retention quotas, restrictions on retaining large salmon, gear types, exclusive catch and release fisheries and complete closures. Harvest in the total Canadian recreational fisheries in 2006 was 35,171 small and large salmon (7% of total returns), of which slightly less than 10% were large (MSW) salmon; this was the lowest total harvest reported in 33 years of record (ICES 2007).

The practice of catch and release has increased in recreational fisheries. In 2006, about 58% of the total number of salmon caught were released (ICES 2007). Under the right conditions, catch and release angling is considered to be a useful management tool (Dempson *et al.* 2002) but still results in some mortality. Water temperature and handling duration are among factors that affect the survival rate of released fish. The incidence of short-term mortalities in Newfoundland were observed to be ~10% (Dempson *et al.* 2002). Values of 3-10% are used when accounting for catch and release-related mortality in stock assessments in Atlantic Canada.

Limited Aboriginal food fisheries take place in eastern Canada, subject to agreements or through licences issued to Aboriginal groups. Most of these fisheries occur in fresh water or in estuaries close to river mouths. Although the reports of harvests are incomplete, the fisheries often affect river-specific stocks. In large areas of eastern Canada, Aboriginal harvests of Atlantic Salmon have been curtailed due to concern about stock status, at times on a voluntary basis. Some of the Aboriginal food fisheries of Labrador take place in what are considered to be coastal waters. These fisheries have moved closer to river mouths and likely harvest few salmon from other than local rivers. The estimated harvest in all Aboriginal peoples' fisheries in 2006 was 59t, the second highest of 17 years of record (ICES 2007).

Commercial fisheries for Atlantic Salmon in Canadian waters, which as recently as 1980 yielded a harvest of 2,412t (ICES 2007), have been closed since 2000. Salmon of Canadian origin are still captured in the marine fisheries of St. Pierre and Miquelon and at West Greenland. Reported harvests of the St. Pierre and Miquelon marine gill net fishery have ranged between 1.5 and 3.6t per year over the past 10 years (ICES 2007). In the context of total harvests, the fishery is small but it is a mixed stock and interception fishery. A recent genetic analysis of a sample of the catches from 2004 indicated that 98% of the fish were of Canadian origin (ICES 2006). As this fishery occurs in a marine area adjacent to the south coast of Newfoundland, it likely has an impact on stocks of the immediate area and the Maritime Provinces.

The fishery of West Greenland is a mixed stock interception fishery and harvests fish of North American and European origin. The salmon caught in that fishery are mostly (>90%) non-maturing 1SW salmon, most of which are destined to return to home waters as multi-sea-winter (2SW primarily) fish. Fish from all multi-sea-winter producing areas of eastern Canada are intercepted in this fishery. In the past ten years, the harvested fish have been predominantly North American in origin. The fishery, which is conducted for local consumption, had a reported harvest of between 2,300 and 4,000 fish of North American origin from 2002 to 2006 (ICES 2007).

Illegal harvests of Atlantic Salmon occur in both marine and fresh waters to varying degrees throughout Atlantic Canada. Poaching in marine waters is more frequent in waters around Newfoundland and Labrador and the Quebec Lower North Shore than elsewhere (DFO and MRNF 2009). In Newfoundland, net-scarred salmon (those that had survived entanglement within nets) approached 10% in some rivers of Newfoundland (Dempson *et al.* 1998). Illegal harvesting is most frequently carried out using gillnets or bait nets, the latter illegally set so as to increase the bycatch of salmon (DFO 2007). Poaching in inland waters is carried out by a variety of means, including jigging and sweeping of pools by nets (DFO 2007). Some management measures deter illegal fishing through fostering community stewardship, targeted enforcement and protecting salmon in vulnerable freshwater habitats. While quantification of the magnitude of mortality associated with illegal fishing is difficult, circumstantial evidence suggests mortality related to illegal fishing can imperil localized stocks (e.g. Cote 2005).

Bycatch associated with monitored commercial fisheries is not considered significant. Bycatch through commercial fisheries is thought to have significantly declined due to the moratorium on some groundfish species since 1992. Dempson *et al.* (1998) indicate very few salmon are caught in both inshore and offshore fisheries. Bait-fishing is also thought to cause minimal bycatch given current bait-fishery restrictions (Reddin *et al.* 2002). Bycatch from Aboriginal fisheries off Labrador do result in salmon mortality. However, these catches count against established quotas, which when reached, trigger additional measures to limit mortality of salmon (ICES 2007). The bycatch of the Ungava Aboriginal fishery is, however, considered “significant” (DFO and MRNF 2009). There are no reported bycatches of salmon from any other Aboriginal fisheries in eastern Canada.

Obstructions can severely reduce the productive habitat and production of salmon (DFO and MRNF 2008). Low head and surmountable dams delay, at the very least, upstream migration until such time as water discharges are adequate for salmon to leap the obstruction. Higher dams equipped with fish passages have varying passage efficiencies, 100% being very uncommon (Fay *et al.* 2006). Even when upstream passage is available, the impoundments behind these dams can delay and/or prevent smolt emigration, increase the energetic costs of smolt movements and, dependent on discharge conditions, can result in increased predation (NRC 2004).

In addition to direct loss of productive habitat from flooding, dams also alter natural river hydrology and geomorphology, interrupt natural sediment and debris transport processes, and alter natural temperature regimes (Ruggles and Watt 1975, Wheaton *et al.* 2004). These impacts can adversely change aquatic community composition and affect the entire aquatic ecosystem structure and function.

Ruggles (1980) identified the following unnatural conditions created by dams that can threaten anadromous salmonid populations: passage over spillways, passage through turbines, passage through impoundments, exposure to atmospheric gas saturation, pollutants, predators, unnatural temperatures, disease organisms and increased vulnerability to exploitation from angling. Smolts are vulnerable to the impacts of dams and may become impinged on screens, entrained in forebays, accrue lethal abrasions or be killed in turbines during downstream migration. Dams can also alter flow patterns of rivers, increase water temperature, and concentrate pollutants, all of which are factors that can adversely affect resident parr and migrating smolts (Foerster 1934, Saunders 1960). Entrainment mortality for salmonids can range between 10-30% at hydroelectric dams (Fay *et al.* 2006). Passage through turbines can also lead to indirect mortality from increased predation and disease (Odea 1999). Where multiple dams exist, the losses of downstream migrating smolts from turbine entrainment are often cumulative and biologically significant (Gibson *et al.* 2009). Because of their larger size, turbine mortality of kelts is expected to be significantly greater than 10 to 30% (FERC 1997). Mortality of salmon in hydropower generation plants, although potentially mitigated with fish passage facilities and water management, can pose a significant threat to the persistence of Atlantic Salmon.

Juvenile Atlantic Salmon can use extensive areas of freshwater habitat (e.g. Robertson *et al.* 2003) and must be able to access feeding and refuge habitat. Lack of habitat connectivity affects the abundance and distribution of Atlantic Salmon populations but may also reduce access to habitats, which improve growth (e.g. Hutchings 1986) and survival (Breau *et al.* 2007).

Improperly designed culverts create barriers to fish passage through hanging outfalls, increased water velocities, or insufficient water velocity and depths within. After a study of culvert installation on the newly constructed Trans-Labrador Highway, Gibson *et al.* (2005) concluded that culverts create more passage barriers to fish passage than other structures. Culverts can also degrade habitat quality through direct loss of habitat through scour, deposition of sediment and loss of food production within the vicinity of the crossing (Bates 2003).

Water withdrawals for agricultural, mining, or other industries can directly impact Atlantic Salmon spawning and rearing habitat (Maine Atlantic Salmon Task Force 1997). They have the potential to expose and reduce salmon habitat and contribute to more variation and higher water temperatures. Adequate water quantity and quality are especially critical to adult migration and spawning, fry emergence and smolt emigration (DFO and MRNF 2008). During summer and winter low flows, juvenile salmon survival is directly related to discharge (Gibson 1993, Cunjak 1988, Cunjak 1996), with better survival in years with higher flows (Ghent and Hanna 1999). As a result, water withdrawals have the potential to limit carrying capacity and reduce parr survival.

Land management activities, particularly land clearing for development, has the potential to negatively affect freshwater habitat of salmon and food sources. Habitat alteration resulting from sedimentation, run-off pollution, channelization and changes to hydrological regimes are all associated with development (Trombulak and Frissell 2000, Wheeler *et al.* 2005, Fay *et al.* 2006).

Juvenile salmon can be adversely affected by contaminants in fresh water. Pesticide effects on salmonids may range from acute (e.g. fish kills in PEI; Cairns *et al.* 2009) to chronic (leading to increased cumulative mortality; DFO and MRNF 2009). Sub-lethal concentrations of contaminants, such as endocrine-disrupting chemicals, may compromise survival of salmon at sea (Fairchild *et al.* 2002, Moore *et al.* 2003, Waring *and* Moore 2004). Sources of these compounds may include agriculture, sewage, pesticide spraying (e.g. forest spraying; Fairchild *et al.* 1999) and industrial effluents (e.g. pulp and paper mills; McMaster 2001). A caging study in the Miramichi River showed a general trend of better feeding and growth in Atlantic Salmon smolts caged at sites with fewer known anthropogenic inputs, of which pulp and paper mill effluent was a major contributor (Jardine *et al.* 2005). In addition, chemical pollution from chlorinated organic compounds, which are widely distributed in the North Atlantic Ocean, has been proposed as a complementary factor affecting the sea survival of Atlantic Salmon (Scott 2001). The limited studies to date have only examined a minute number of the vast variety of chemicals currently being used and introduced.

Acidification of fresh water in eastern Canada is primarily a result of depositions of airborne pollutants originating in the central U.S. and Canada, though inputs are augmented by local sources as well (DFO 2000). Currently, acid impacts on Atlantic Salmon are most pronounced in the Southern Upland region of Nova Scotia (DU 14) where 22% of rivers are acidified and have lost populations and a further 31% are moderately impacted by acidification and maintain remnant populations (DFO 2000). Assuming a smolt-to-adult return rate of 5%, a value higher than is presently being observed, acidification impacts will likely result in the extirpation of 85% of the Southern Upland populations. The underlying geology of the Southern Upland is the principle reason for the vulnerability to acidification.

Other areas in Atlantic Canada that are somewhat vulnerable to the effects of acid depositions are southwestern and northeastern Newfoundland (Environment Canada 2004). Although there has been a reduction in sulphate emissions and depositions, there has not been a corresponding increase in pH or acid neutralizing capacity in these areas. Furthermore, at the projected sulphate deposition rates, the time for recovery of base cations in these catchments is 60-80 years (Clair *et al.* 2004). Based on the cumulative effects and extirpations, the estimated time to recovery for affected drainages, and the large area affected, acidification remains a significant threat to one DU (14, Nova Scotia Southern Upland) and is a burden if not a threat to perhaps one other (DU 4) in Newfoundland.

Infiltration of sediment into stream bottoms has been suggested as a cause for significant decrease in the survival, emergence and over-wintering success of Atlantic Salmon juveniles (Chapman 1988). Sediment size and movement in a stream (bedload) is a natural process; however, a multitude of impacts can greatly increase the input and accumulation of sediments to streams (Meehan 1991, Wheeler *et al.* 2005). The result is the loss of habitat as interstitial spaces become filled with sediment. All but the oldest of juvenile salmon occupy interstitial spaces at some stage and therefore exceeding the equilibrium input of sediments into streams can have devastating effects. As little as 0.02% silt has been shown to decrease the survival of eggs to the pre-eyed stage by 10% (Julien and Bergeron 2006). As stated above, sedimentation is often a by-product of road construction, urban development, agriculture and some industries.

Aquaculture is an industry associated with much controversy as inferences have been made that associate the decline in European wild salmon stocks with the rise in farmed salmon production (e.g. Gausen *and* Moen 1991, Heggberget *et al.* 1993, Hansen *et al.* 1997). Similar concerns have been voiced in eastern Canada, as growth of the Canadian industry has coincided with severe declines in wild populations in nearby rivers in the Bay of Fundy (DU 15, 16) and the Bay D'Espoir region (DU4) of the south coast of Newfoundland (Carr *et al.* 1997, Amiro 1998, Chang 1998, Dempson *et al.* 1999).

The concern for wild stocks is based on the potential for interactions that result in inter-breeding and subsequent loss of fitness, competition for food and space, disruption of breeding behaviour, and transmission of disease (Cairns 2001). In North America, farm-origin salmon, have been reported in 87% of the rivers investigated within 300 km of aquaculture sites (Morris *et al.* 2008). Though the abundance of farmed salmon in rivers is highly variable, it can exceed those of wild fish (Jones *et al.* 2006, Morris *et al.* 2008). There is strong evidence for the introgression of genetic material from European-origin aquaculture salmon into some wild Atlantic Salmon populations within the inner Bay of Fundy (Patrick O'Reilly, pers. comm.).

Even small percentages of escaped farmed salmon have the potential to negatively affect resident populations, either through demographic or genetic changes in stock characteristics (Hutchings 1991). There have been many reviews and studies showing that the presence of farmed salmon results in reduced survival and fitness of wild Atlantic Salmon, through competition, interbreeding and disease (e.g., Gross 1998, Fleming *et al.* 2000, NRC 2002, 2004, McGinnity *et al.* 2003). For example, an experimental cross between 4th-generation farmed Atlantic Salmon of the Saint John River and wild individuals from the Stewiacke River, showed a significant decrease in F1 survival to the pre-eyed embryonic stage relative to pure crosses (Lawlor 2003). The use of more exotic species (e.g. rainbow trout) in and around salmon rivers could also pose a problem with escapes into the wild (see interspecific interactions).

Another concern related to aquaculture is the possibility of disease/parasite transmission from artificially propagated fish to wild stocks. In Norway many salmon populations have been destroyed by the parasite *Gyrodactylus salaris* (Heggberget *et al.* 1993, McVicar 1997) and over 70 rivers affected with furunculosis (Johnsen *and* Jensen 1994; in both cases the outbreaks originated with hatchery-propagated salmonids. However, in North America there is no evidence to indicate that farmed salmon have transferred these diseases to wild fish (DFO 1999).

It has been suggested that intensive aquaculture may cause salmon to alter migratory behaviour (Amiro 2001), and that attraction of predators such as seals to aquaculture facilities might result in an increased rate of predation of wild fish in the area (Cairns and Meerburg 2001), but both of these suggestions remain unverified.

As outlined in Interspecific Interactions, invasive and/or introduced species have potential to negatively interact with Atlantic Salmon, particularly in freshwater. Potential interactions include predation, competition for habitat, food and mates as well as hybridization. In the Great Lakes, Zebra Mussels (*Dreissena polymorpha*) and Alewife (*Alosa pseudoharengus*) may have created conditions that are less conducive to restoration efforts. The latter has also been implicated in the collapse of Lake Ontario Atlantic Salmon. Endemic salmon may have suffered the effects of thiamine deficiency (including mortality and impaired ability to reach spawning grounds) as alewife became a prominent food source (Ketola *et al.* 2000). In general, negative interactions between salmon and non-native species are often context-specific or not well understood.

In areas where populations have collapsed, further declines caused through inbreeding depression and abnormal behaviour associated with low population size are a concern (e.g. iBoF; COSEWIC 2006b).

Cairns (2001) noted that it is very improbable that the decline in Atlantic Salmon is due to any single cause, and factors contributing to a decline are likely to have acted in a cumulative manner (see projections of Gibson *et al.* 2009 for an example of cumulative interactions of stressors). Directed fishing and habitat alterations are considered in many DUs to have a medium effect on populations (DFO and MRNF 2009). A semi-quantitative assessment, by regional fisheries scientists and managers, of the impact of habitat-related threats to salmon is summarized by DU in Table 3 (taken from DFO and MNFR 2009). Potential sources of mortality were assessed with respect to the proportion of salmon that would be affected, and the time frame in which salmon had been vulnerable to the threat. The most wide-ranging habitat threats to Atlantic Salmon originate from transportation infrastructure, agriculture, forestry and mining operations, and municipal waste-water discharge. The least severely threat-impacted areas are in Quebec, Newfoundland and Labrador (DUs1-9). Conversely, the Maritime Provinces (DUs 14-16) are the most severely threat-impacted with several threats affecting > 30% of salmon or a loss of > 30% of spawners (Table 3). Salmon of DU 14 (Nova Scotia Southern Upland) are severely impacted by acid rain, which has caused the loss of populations in several of the 63 rivers within the DU. In combination with the persisting low marine survival (ecosystem change) listed for DUs 12-16, acid rain is threatening the loss of the majority of the remaining salmon populations within that area (Amiro 2000, DFO 2000). Based on the ubiquitous effects poor marine survival is having on Atlantic Salmon populations, ecosystem effects (e.g. Friedland 1998) should be considered a threat for all DUs.

Table 3. Summary assessment of threats to Atlantic Salmon (in terms of salmon affected and lost to habitat alterations) for proposed designatable units (DU) as reported by fisheries managers (modified from DFO and MRNF 2009). Dark shading highlights '>30% of salmon affected'; light shading is '5-30% affected' and no shading is <5% affected-often not applicable unassessed, uncertain.

			Salmon Affected : Spawners Lost													
			Regulated Habitat Alterations											Other		
Proposed DU	**Atlantic Salmon Conservation Unit**	**No. salmon rivers**	**Municipal waste water**	**Industrial effluents (pulp *and* paper, etc.)**	**Hydroelectric *and* water storage dams**	**Water extraction**	**Urbanization (hydrology)**	**Transportation Infrastructure (roads culverts *and* fish passage)**	**Aquaculture siting**	**Agriculture, forestry, mining**	**Dredging**	**Cumulative**	**Shipping transport**	**Air pollutants / acid rain**	**Ecosystem change**
DU2	1. North Labrador	28	L:L	L:L	L:L	L:L	L:L	L:L	L:L	L:L	L:L	**L:L**	L:L	L:L	LU:LU
DU2	2. Lake Melville Labrador	20	L:L	L:L	L:M	L:L	L:L	M:M	L:L	L:L	L:L	**U:U**	L:L	L:L	LU:LU
DU2	3. South Labrador	41	L:L	L:L	L:L	L:L	L:L	M:M	L:L	L:L	L:L	**U:U**	L:L	- : -	LU:LU
DU3	4. NE Coast NF	127	M:M	L:L	M:M	L:L	L:L	M:M	L:L	M:M	L:L	**U:U**	L: -	- : -	LU:LU
DU4	5. SE Coast NF	49	L:L	L:L	L:L	L:L	L:L	M:M	L:L	M:M	L:L	**U:U**	U:U	MU:MU	LU:LU
DU4	6. South Coast NF	55	L:L	- :L	M:M	L:L	L:L	L:L	M:M	L:L	L:L	**U:U**	- : -	MU:MU	LU:LU
DU5	7. SW Coast NF	40	L:L	L:L	L:L	L:L	L:L	U:U	L:L	M:M	L:L	**U:U**	- : -	- : -	LU:LU
DU6	8. NW Coast NF	34	L:L	L:L	L:L	L:L	L:L	L:L	L:L	L:L	L:L	**L:L**	L:L	- : -	LU:LU
DU12	9. Northern NB	15	L:L	L:L	LM:LM	L:L	L:L	M:M	N/A	M:M	L:L	**M:M**	U:U	L:U	LU:LU
DU12	10. Central NB	25	LM:L	L:L	L:L	L:L	L:L	M:M	N/A	LM:L	L:L	**M:M**	U:U	L:U	LU:LU
DU12	11. PEI	5ª	L:L	N/A	MH:MH	L:L	L:L	MH:MH	L:L	MH:MH	L:L	**MH:MH**	U:U	U:U	LU:LU
DU12	12. NE NS	33	LM:LM	L:L	L:L	L:L	L:L	M:M	N/A	L:L	L:L	**M:M**	U:U	U:U	LU:LU
DU13	13. CB East Highlands	8	M:L	U:U	L:L	L:L	H:U	H:U	H:U	H:U	L:L	**U:U**	H:U	L:L	H:U
DU13	14. CB East Lowlands	21	H:U	U:U	L:L	L:L	H:U	H:U	H:U	H:U	L:L	**MH:U**	H:U	L:L	H:U
DU14	15. NS Southern Upland	63	H:U	L:L	H:M	U:U	H:U	H:U	U:U	H:U	L:L	**H:U**	L:L	H:H	H:U
DU15	16. IBoF NS/NB	37	H:U	L:L	M:L	U:U	H:U	H:U	H:U	H:U	L:L	**H:M**	L:U	L:L	H:H
DU16	17. OBoF NB	17	H:U	H:U	H:M	MH:U	H:U	H:U	M:U	H:U	L:L	**H:M**	H:U	U:U	H:H
DU12	18. Chaleur Bay PQ	5	L:L	L:L	N/A	L:L	L:L	L:L	N/A	L:L	- : -	**L:L**	- : -	L:L	L:L
DU12	19. Gaspé Peninsula PQ	10	U:U	U:U	N/A	N/A	L:L	L:L	U:U	U:U	- : -	**L:L**	U:U	U:U	U:U
DU12	20. Lower St. Lawrence N Shore Gaspé PQ	9	L:L	N/A	L:L	L:L	L:L	L:L	N/A	L:L	- : -	**L:L**	- : -	L:L	L:L
DU10	21. Appalachian Region PQ	0													
DU10	22. Quebec City Region PQ	3	L:L	U:U	U:U	U:U	U:U	L:L	U:U	U:U	U:U	**U:U**	U:U	U:U	M:M
DU10	23. Saguenay-Lac Saint-Jean PQ	4	L:L	U:U	U:U	U:U	U:U	M:U	U:U	- : -	U:U	**U:U**	U:U	U:U	H:L
DU8	24. Upper North Shore PQ	12	N/A	N/A	L:L	L:L	N/A	N/A	N/A	UL:UL	N/A	- : -	N/A	N/A	U:U
DUs7,8	25. Middle North Shore PQ	17	N/A	N/A	L:L	N/A	N/A	N/A	N/A	UL:UL	N/A	- : -	N/A	N/A	U:U
DUs2,7	26. Lower North Shore PQ	21	N/A	N/A	L:L	N/A	N/A	N/A	N/A	N/A	N/A	- : -	N/A	N/A	U:U
DU9	27. Anticosti PQ	25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	U:U	N/A	- : -	N/A	N/A	U:U
DU1	28. Ungava PQ	4	L:L	N/A	N/A	L:L	L:L	L:L	L:L	L:L	L:L	**L:L**	U:U	U:U	U:U

a- Where 'salmon affected' symbol 'L' is < 5% of salmon in DU are affected; 'M' is 5-30% are affected, 'H' is >30% are affected and 'U' is uncertain; 'salmon lost' symbol 'L' is < 5% of salmon spawners in DU are lost; 'M' is 5-30% are lost, 'H' is >30% are lost and 'U' is uncertain; N/A = Not Applicable and '-' = Not Assessed.

ª Cairns *et al.* 2009 state there were at least 22 salmon rivers in PEI.

SPECIAL SIGNIFICANCE[xxi]

Atlantic Salmon are contributors to both freshwater and marine ecology, moving nutrients between ecosystems as migrants and linking energy flow as prey and as predators within ecosystems. They are the principle host species for the Eastern Pearl Mussel (*Margaritifera margaritifera*) and possibly the Dwarf Wedgemussel (*Alasmidonta heterodon*) (Hanson *and* Locke 2001, National Recovery Team 2002). They are traditionally used by (i) over 49 First Nations and Aboriginal organizations, (ii) commercial fisheries, and (iii) recreational fisheries (DFO and MRNF 2009). They are also the subjects of local art, science and education and symbols of heritage and health to peoples of Canada.

EXISTING PROTECTION, STATUS, AND RANKS

The Atlantic Salmon is currently listed or ranked with several international and national bodies. In the United States of America, endemic populations in Maine have Endangered status under the *U.S. Endangered Species Act*. In April 2006, COSEWIC assessed the Atlantic Salmon Inner Bay of Fundy population as Endangered and the Lake Ontario population as Extirpated. The Atlantic Salmon Inner Bay of Fundy population is currently listed as Endangered under Canada's *Species at Risk Act*, and the Lake Ontario population is currently listed as Extirpated under Ontario's *Endangered Species Act*, 2007. Fisheries management actions also provide significant protection for Atlantic salmon. These measures are complex and vary across jurisdictions but generally include: fishery closures, limitations on gear types (both Aboriginal and recreational), seasonal restrictions, retention and release policies (e.g. quotas, catch and release, no retention of MSW fish). Salmon habitat is also protected and managed under the *Fisheries Act* by the Department of Fisheries and Oceans. Under provincial legislation the Atlantic Salmon is listed as Extirpated in Ontario, Sensitive in New Brunswick, Secure in Nova Scotia, Quebec, and Newfoundland and Labrador, and not assessed in Prince Edward island.

NON-LEGAL STATUS AND RANKS[xxii]

Internationally, Atlantic Salmon are listed as Least Concern on the IUCN Red List of Threatened Species (last assessed 1996). They are also ranked by the WWF on a per river basis throughout its global range, as 15% Extinct, 12% Critical, 20% Endangered, 10% Vulnerable, and 43% healthy (N = 2,005 rivers in 19 countries).

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Dr. Adams completed his B.Sc. at St. Mary's University and his M.Sc. and Ph.D at Dalhousie University, both located in Halifax, Nova Scotia, Canada. Dr. Adams completed a post-doc at Memorial University of Newfoundland and now works with the Department of Natural Resources, Goverment of Newfoundland and Labrador. Dr. Adams has over 15 years experience studying salmonid fish, primarily Atlantic salmon.

Dr. Cote received a B.Sc in Biology from Wilfrid Laurier University (1996) and a Ph.D. in Biology from the University of Waterloo (2000). He has been an aquatic ecologist with Parks Canada (Terra Nova National Park) since 2000 and has 17 years experience studying emperilled marine and anadromous fish populations. He holds an adjunct faculty position at Memorial University of Newfoundland and has authored 18 primary and 8 secondary publications.

Appendix 1: River-specific salmon abundance trend information, presented by region (taken from Gibson *et al.* 2006).

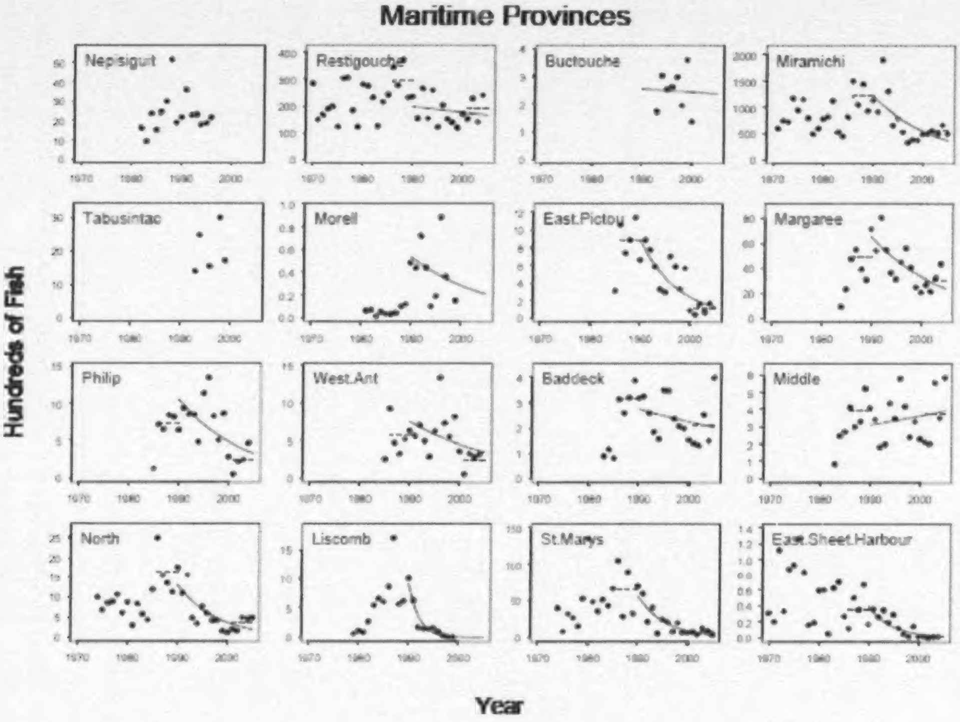


Figure A1. Trends in abundance of salmon populations in the Maritime Provinces from 1970 to 1990. The curved solid line shows the trend from 1990 to 2005 obtained from a log-linear model. The dashed lines show the 5-year average population sizes for the time periods ending in 1990 and 2005 (taken from Gibson *et al.* 2006).

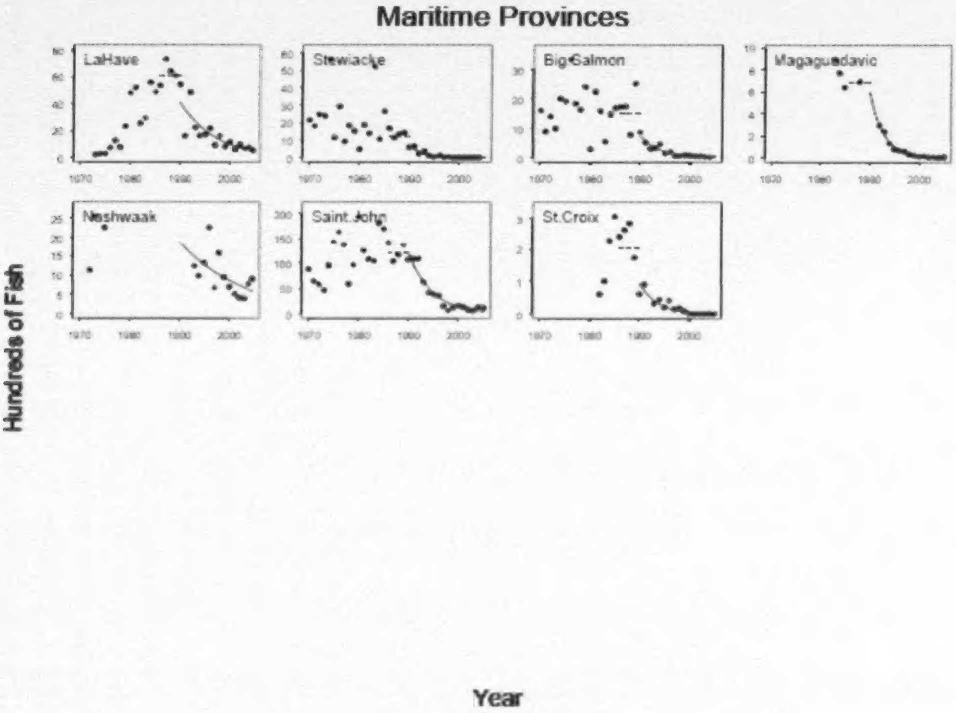


Figure A1. (con't.). Trends in abundance of salmon populations in the Maritime Provinces from 1970 to 1990. The curved solid line shows the trend from 1990 to 2005 obtained from a log-linear model. The dashed lines show the 5-year average population sizes for the time periods ending in 1990 and 2005 (taken from Gibson *et al.* 2006).

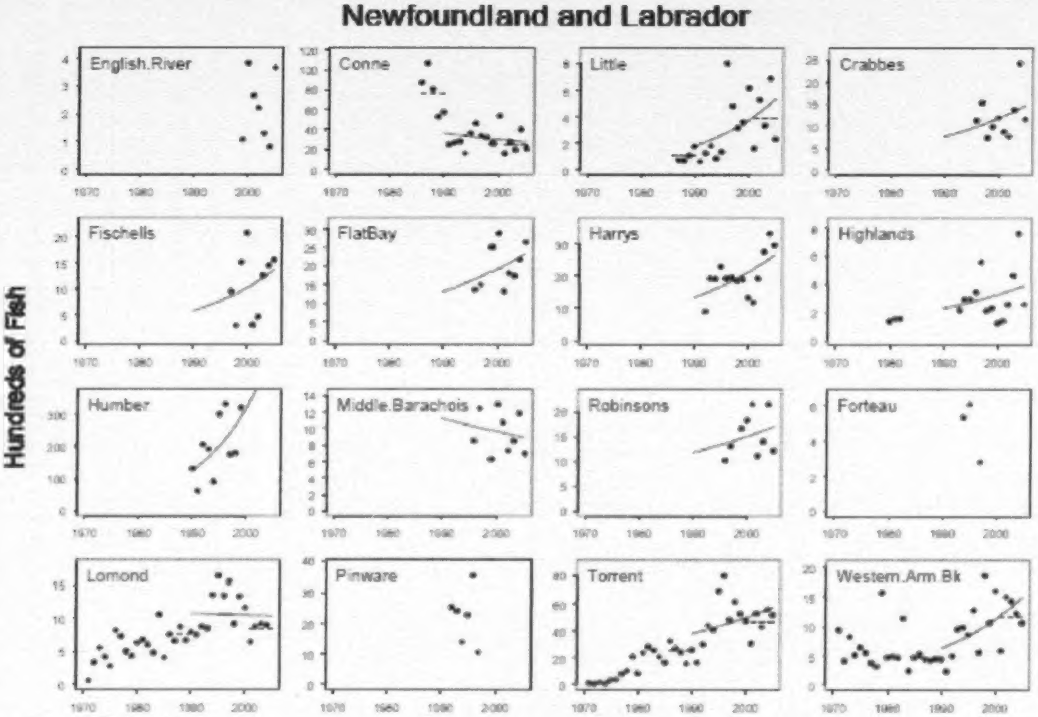
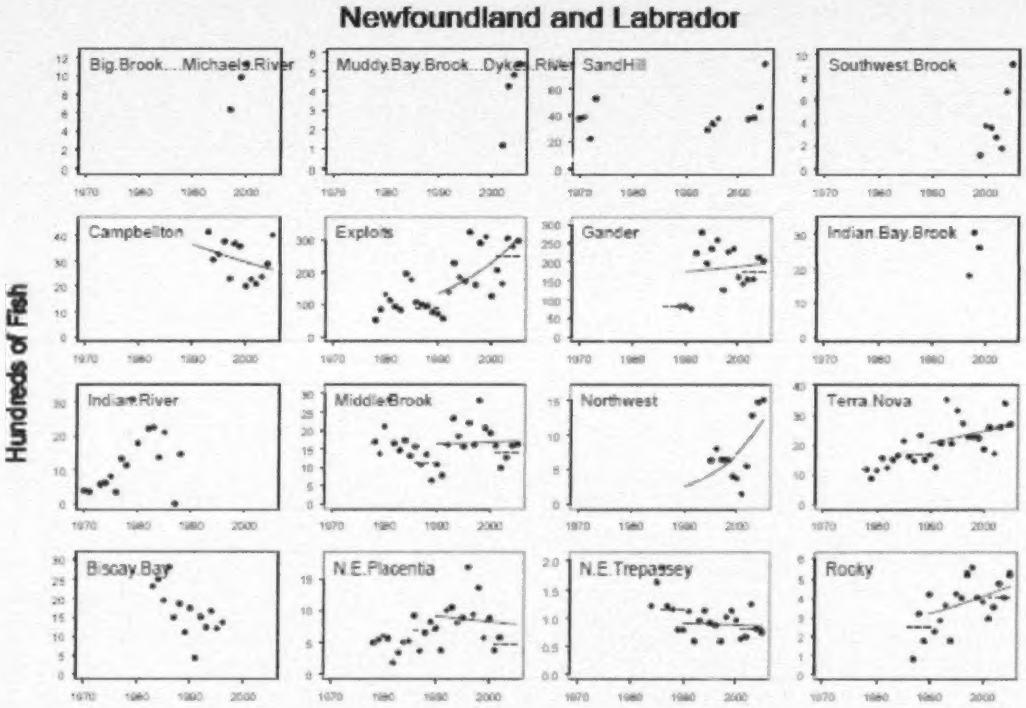


Figure A2. Trends in abundance of salmon populations in Newfoundland and Labrador from 1970 to 1990. The curved solid line shows the trend from 1990 to 2005 obtained from a log-linear model. The dashed lines show the 5-year average population sizes for the time periods ending in 1990 and 2005 (taken from Gibson *et al.* 2006).



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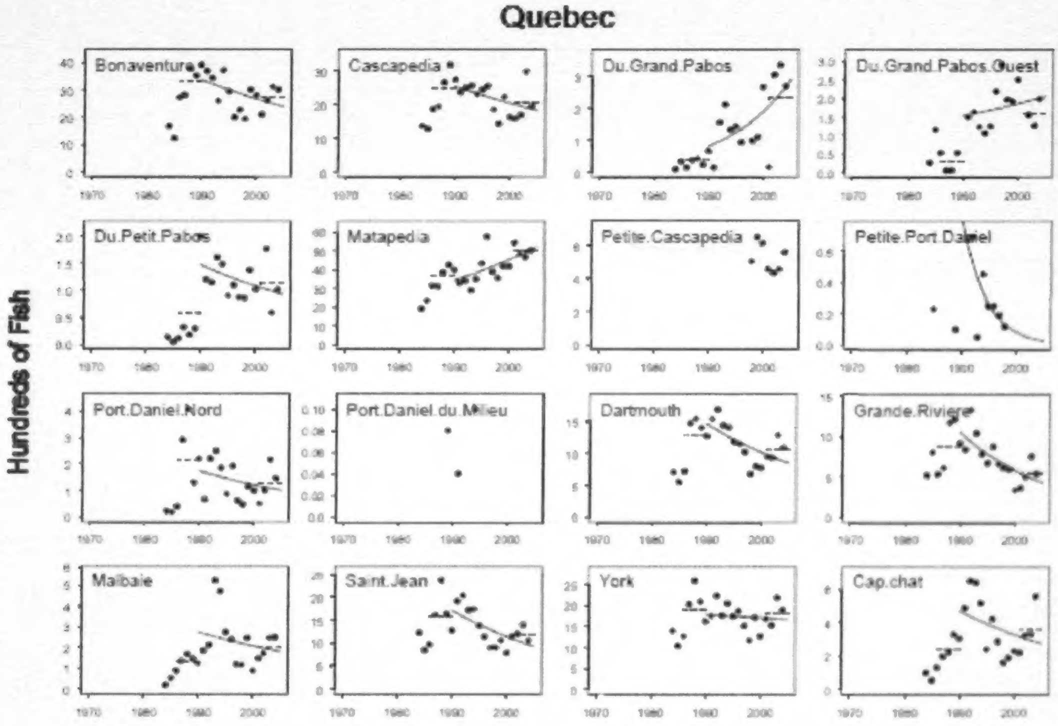
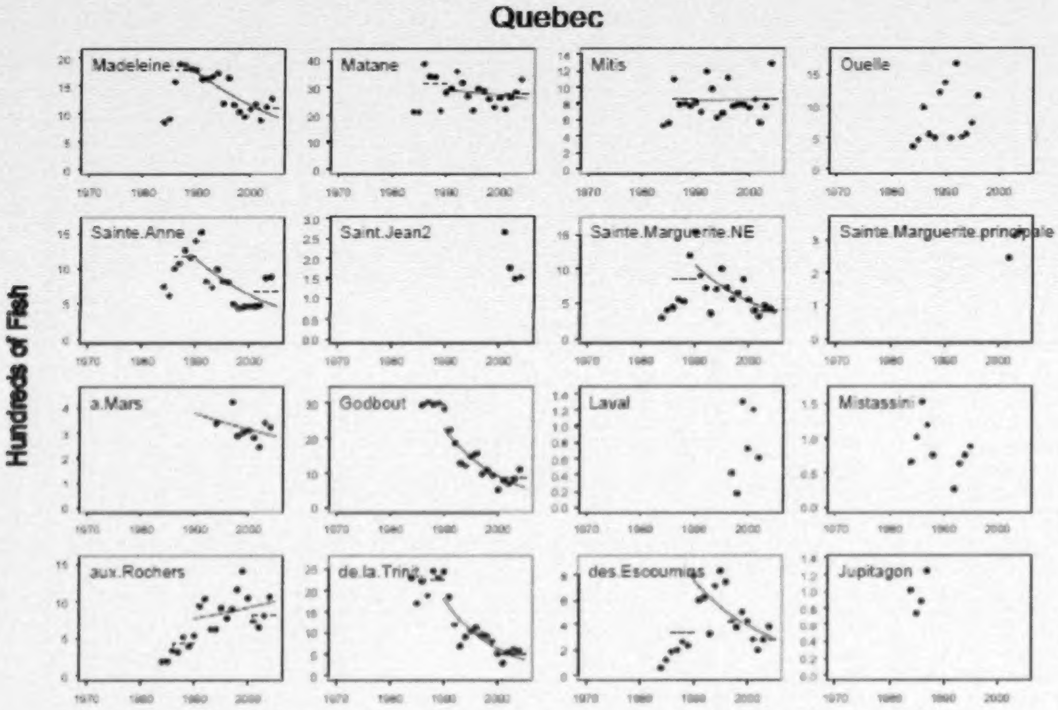


Figure A3. Trends in abundance of salmon populations in Quebec from 1970 to 1990. The curved solid line shows the trend from 1990 to 2005 obtained from a log-linear model. The dashed lines show the 5-year average population sizes for the time periods ending in 1990 and 2005 (taken from Gibson *et al.* 2006).



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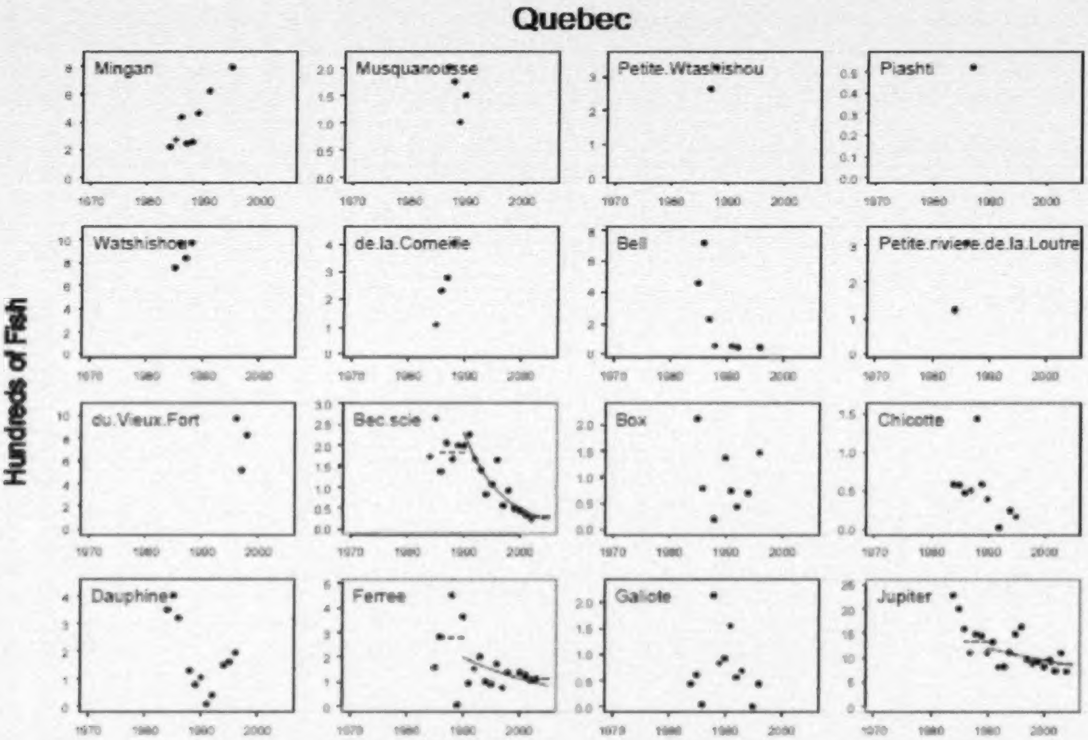

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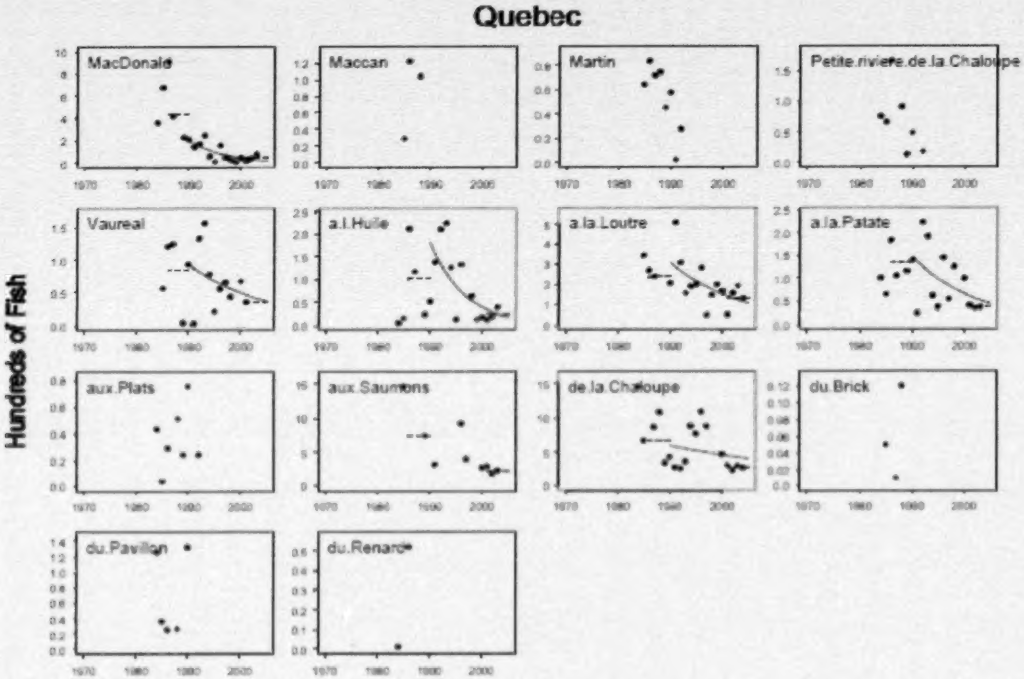

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[i] This section is taken from COSEWIC 2006a.

[ii] Elements of this section are copied, abstracted and/or synthesized from DFO *and* MRNF (2008).

[iii] Elements of this section have been copied, abstracted and/or synthesized from COSEWIC (2006a).

[iv] This section was taken from COSEWIC (2006a).

[v] This section was taken from COSEWIC (2006b).

[vi] Note that the number of salmon rivers presented by the WWF does not correspond with the estimate provided by COSEWIC (2006b) in Figure 2.

[vii] Elements of this section have been copied, abstracted and/or synthesized from DFO (2000), Amiro (2006), COSEWIC (2006a, 2006b) and DFO and MRNF (2008).

[viii] Elements of this section have been copied, abstracted and/or synthesized from Reddin (2006), COSEWIC (2006a, 2006b) and DFO and MRNF (2008).

[ix] Elements of this section have been copied, abstracted and/or synthesized from DFO (2000), Amiro (2006), COSEWIC (2006a, 2006b) and DFO *and* MRNF (2008).

[x] Elements of this section have been copied, abstracted and/or synthesized from COSEWIC (2006b), DFO and MRNF (2008) and DFO and MRNF (2009).

[xi] Elements of this section have been copied, abstracted and/or synthesized from DFO *and* MRNF (2008).

[xii] Elements of this section have been copied, abstracted and/or synthesized from Cairns (2006) and DFO and MRNF (2008).

[xiii] Elements of this section have been copied, abstracted and/or synthesized from DFO (2000) and COSEWIC (2006a).

[xiv] Elements of this section have been copied, abstracted and/or synthesized from DFO and MRNF (2008), DFO *and* MRNF (2009), Wesley *et al.* (submitted) and COSEWIC (2006a, 2006b).

[xv] Modal smolt ages were derived from Appendix 3 (large and small salmon combined) in Chaput *et al.* (2006a), except for DU 7 (Appendix 1 - small salmon), DU 8 (Appendix 2 - large salmon) and DU 10 (estimated from Figure 3), where data were lacking.

[xvi] This DU was listed as "extirpated" in COSEWIC 2006a; however, current interpretation of the meaning of "DUs" requires that if a DU is lost, its unique elements cannot be recovered. As such, the authors have been advised that "extinct" is a more appropriate description.

[xvii] Elements of this section have been copied, abstracted and/or synthesized from DFO *and* MRNF (2009)

[xviii] Large salmon in DU 3 are comprised almost exclusively of repeat spawning grilse as opposed to maiden multi-sea -winter fish.

[xix] This DU was listed as "extirpated" in COSEWIC 2006a; however, current interpretation of the meaning of "DUs" requires that if a DU is lost, its unique elements cannot be recovered. As such, "extinct" is a more appropriate description.

[xx] Elements of this section have been copied, abstracted and/or synthesized from Cairns (2001), Dempson *et al.* (2008), COSEWIC (2006a, 2006b), DFO *and* MRNF (2008) and DFO *and* MRNF (2009).

[xxi] Elements of this section have been copied, abstracted and/or synthesized from COSEWIC (2006b).

[xxii] Elements of this section have been copied, abstracted and/or synthesized from COSEWIC (2006a).